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Vol. XVI MAY, 1911 No. 5

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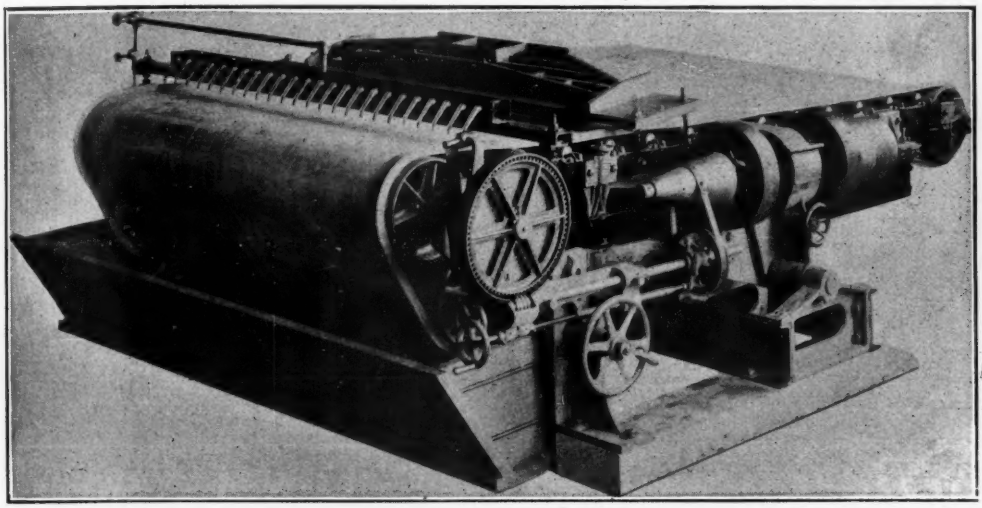

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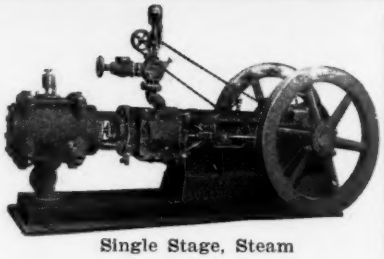

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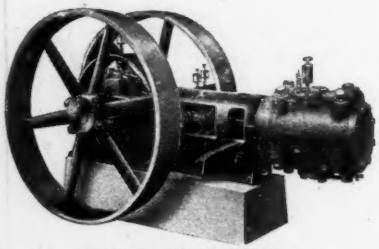

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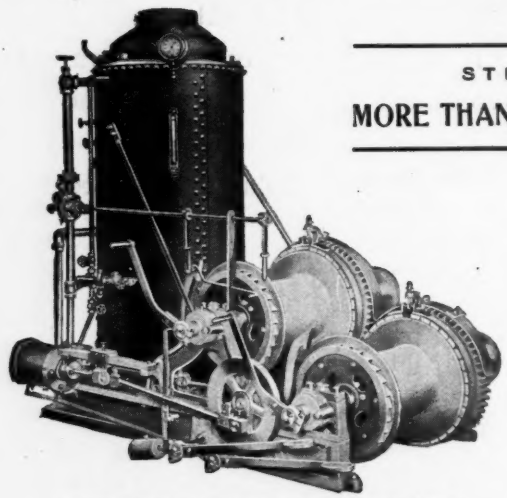

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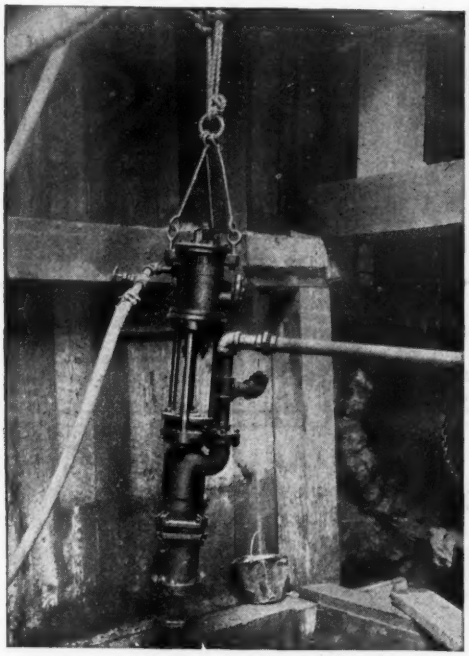

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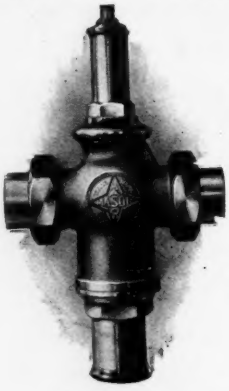

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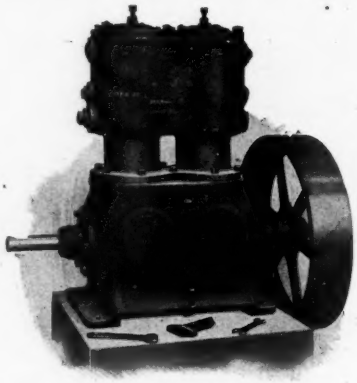

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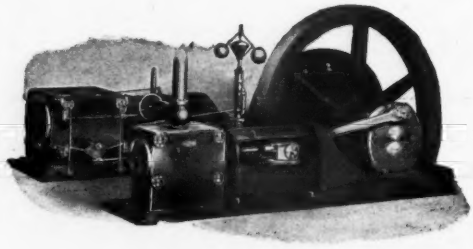

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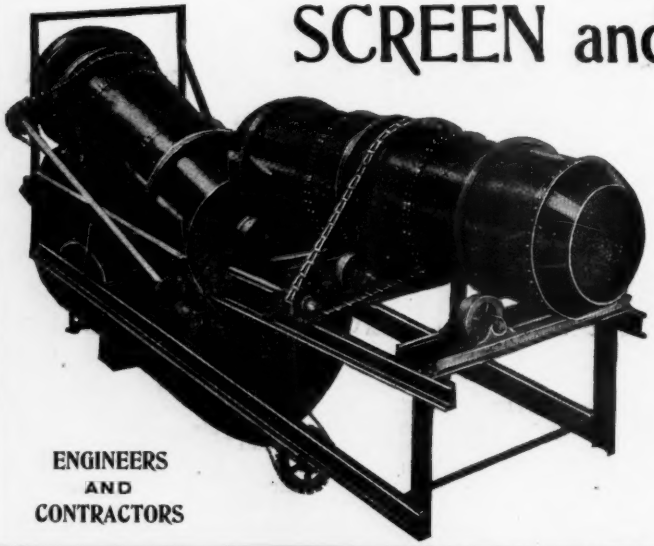

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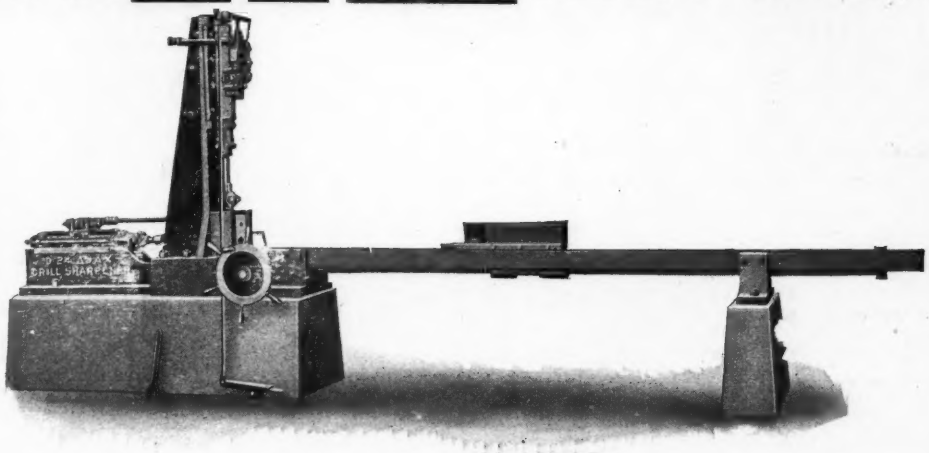

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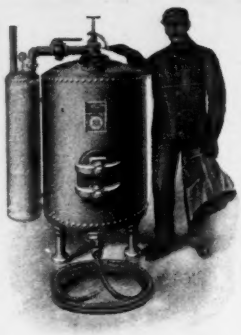

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PREFACE TO THE SECOND EDITION

This edition has been revised and substantially enlarged. Among the principal additions are some 90 pages of text and 63 illustrations, relating to the construction and operation of rock-drills, coal-cutting machines and channeling machines. This material is contained in Chapters XX, XXI, XXII, and XXIII. The detailed records of work of machine drills, in Chapters XX and XXI, I believe, will be found useful. Most of the data has not before been in print.

In Chapter III the theory of the compression of air is presented in greater detail, together with its applications to the operation and performance of compressors. The deductions of the more important formulæ are also given, such as those used for calculating the horse-power required for single- and multiple-stage compression. In this connection I desire to acknowledge the kind assistance of Professor Charles E. Lucke, of Columbia University, and Professor H. J. Thorkelson, of the University of Wisconsin. To Dr. Lucke my thanks are due for the use of his valuable, and hitherto unpublished, notes relating to the work cycles of air compression, with and without clearance. I would call attention also to the records of compressor tests in the latter part of Chapter X. These comprise a few typical tests, selected from a large number recently made by Mr. R. L. Webb, Mechanical Engineer, on compressors of different kinds in a well-known Canadian mining district.

Other new material has also been added, relative to the piston clearance of the air cylinders of compressors, and the ratio of inlet valve area to cylinder area. Numerous minor additions to the text have been made, together with corrections and alterations where required. The new matter aggregates some 135 pages of text and 87 illustrations. Many of the illustrations have been furnished by the respective makers of the machinery, to whom credit is duly given. In preparing this revision I have kept in mind certain kindly criticisms and suggestions received from readers of the first edition.

R. P.

NEW YORK, June, 1910.

8vo, xvi + 502 pages, 209 figures. Cloth, $3.50 net (15/- net)

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Theory and Computations

AN ENGINEER'S HANDBOOK

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I. Formulas for Work; Temperature Constant and Varying, Incomplete Expansion—Effect of Clearance in Compression—Clearance and Compression in Expansion Engines—Effect of Heating Air as It Enters Cylinders—Temperature Change in Compression or Expansion — Density at Given Temperature and Pressure—Cooling Water Required—Reheating and Cooling — Compounding and Proportions For — Work in Compound Compression and under Variable Intake Pressure — Exhaust Pumps—Efficiency when Air is Used without Expansion—Variation of Free Air Pressure with Altitude.

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VI. AIR-LIFT PUMP. General Discussion — Theory—Design—As a Dredge Pump—For Testing Wells—Data on Operation.

VII. EXAMPLES AND EXERCISES.

PLATES AND TABLES.

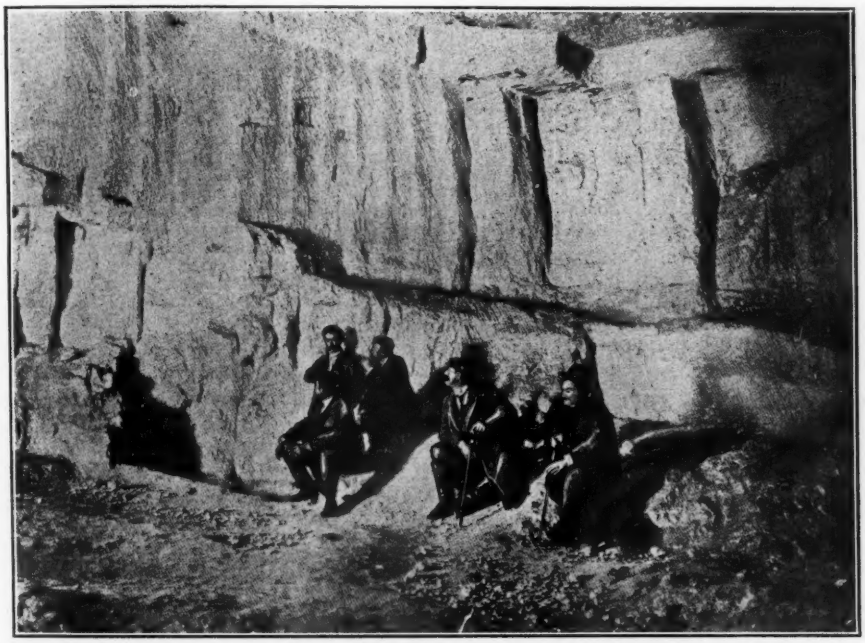
APPENDIX A. Drill Capacity Tables.

APPENDIX B. Data on Friction in Air Pipes.

COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC.

Vol. XVI MAY, 1911 No. 5



KING SOLOMON'S QUARRIES.

KING SOLOMON'S QUARRIES

The interesting photo here reproduced from *Stone,* for which publication it was originally made, should be of wide general interest, and we may assume its appeal to our own readers in that compressed air is here so conspicuous by its absence, showing one of the marked contrasts between the ancient and the modern ways of working.

Thomas R. Wallace, U. S. consul at Jerusalem, recently reported concerning the vast abandoned and long forgotten quarries beneath the northern portion of the Holy City. They were discovered a few decades ago by accident. A Dr. Barclay, an American tourist, was out hunting, and as he passed along the north wall of the city his dog disappeared beneath the wall. Following him Dr. Barclay discovered the entrance, then almost entirely closed with rubbish, of these grottoes or quarries. This discovery led to their exploration, and it was found that vast quantities of white stone had been taken out for building purposes, enough, it has been estimated, to build the present Jerusalem within the wall two or three times over.

The exceeding whiteness of the stone, its nearness to the temple area, its suitability for building purposes, being soft when first quarried, but hardening on exposure, the great chamber deep in stone chippings, where vast quantities of the quarried stone had been cut into shape, suggesting the allusion to the temple having been put together without the sound of hammer or saw—all these and other considerations conspired to establish the idea that has since taken hold on the public mind, that here indeed was that of which Josephus and the Old Testament spoke in connection with the building of the temple.

The quarries are entirely substerranean and reach to a great depth, comprising many separate chambers. The photo was, of course, taken by flashlight, and from it we get a good idea of how everything was left by the workmen after they had removed the last row of building blocks. The manner of hewing out the deep grooves on each side of the block, and at its top and bottom, and the way the wedges were introduced at the back for breaking the block from its bed rock, can all be plainly traced, as well as the niches for the workman's lamps, so placed that the light would shine into the cut.

COMPRESSED AIR EXPLOSIONS

By W. L. Saunders.

Men in charge of compressed air plants should watch and study carefully each case where ignition or explosion occurs in compressed air pipes and passages. It is a dangerous thing to maintain a large volume of compressed air in a condition where there is a liability of ignition of corbonaceous matter.

A case has recently been brought to my attention where a typical plant of air compressors, consisting of two straight line machines with compound air cylinders, was working in an engine room pumping air at a pressure of about 90 pounds into a receiver from which the air was led a distance of about 150 feet to the mouth of a shaft. An explosion took place at the mouth of the shaft, the pipe and tee (6″) were ruptured, about 6 feet of the pipe breaking open and the tee being shattered. The pipe down in the shaft, which was held together by flanged couplings, was broken to the extent of one section of pipe only, this section, together with the flanges, being thrown out and the flanges broken.

One peculiarity about this construction, which may have had something to do with the explosion, is that the air pipe line leading from the receiver to the mouth of the shaft was not on a level, but was depressed at the receiver, which means that there was a pocket in this line near the receiver, which might have accumulated moisture, oil, carbon or other material. The first lesson to be learned from this explosion is that under no circumstances should such a pocket exist in an air pipe line. In this case there appears to be no reason for such construction, though at times, and particularly in mines, it may be impracticable to prevent a condition like this, but in such cases the pocket should be accessible and should be provided with means for draining, preferably in the shape of a small air receiver or enlarged section of pipe.

This plant was provided with a Pittsburg recording pressure gage. This recording gage record shows a pressure running uniformly at about 90 pounds per square inch during the day, until about half past 3 o'clock in the afternoon, when the line forms a right angle, going abruptly in a straight line up beyond the limits of the gage. Evidently when this explosion took place the needle was driven upward until it stuck.

An investigation in this case led immediately to the question as to what oil was used. A sample being furnished and analyzed, showed a flash test of 360 degrees, Fahrenheit; which cannot be called a low flash test, though it might have been higher. Oil showing a flash test of 360 degrees is fairly good oil for this purpose.

It is impossible to determine definitely in a case like this where the explosion or ignition began, we simply know that the air pipe in certain places broke, and as these places were connected through an uninterrupted compressed air passage with the interior of the compressor cylinder, through the receiver, it is reasonable to say that the high pressure which this explosion or ignition produced extended all along the line, and that the rupture took place at the weakest points. A pipe joint, especially where it connects with a cast iron fitting, is naturally weaker than an air receiver or the discharge passages of an air compressor cylinder.

It is unreasonable to suppose that ignition actually took place at the point of fracture.

It is more reasonable to infer that the beginning was in the air cylinder itself or at a discharge valve, and it is plain that compressed air when charged with vapor of oil will ignite or explode along the entire line, provided a spark initiates it. What takes place in the cylinder of an automobile is probably what took place in the case of this explosion. An automobile engine gets its power through the ignition of a chamber of air compressed and charged with an explosive vapor—gasoline. The proportion of gasoline to air is very small, the gasoline, however, being so thoroughly distributed throughout the air that it heats or ignites the air at all points, causing rapid expansion.

The word explosion is a relative term. Steam may be said to explode when it pushes the piston of an engine, through an effort to occupy more space, because the original particles of water are converted into steam by heat. An air receiver filled with compressed air and heated will have an explosive tendency for the same reason. In other words, an explosion may be said to be the result of the tendency of a confined substance to occupy more space, and if that action takes place slowly it is called an expansion. If it takes place rapidly or suddenly it is called an explosion.

In the automobile cylinder, for instance, we cannot call it an explosion because it acts harmoniously and practically, producing mechanical power. If the ports and passages of an automobile engine were made too light the result would be an explosion, or, if we inserted gun powder or dynamite in the cylinder instead of gasoline, we would produce an excessive pressure which would rupture the engine; this would be an explosion.

Another point to be considered in studying a compressed air explosion is that the quantity of carbon that is present in the air has a good deal to do with the seriousness of the explosion. It is not uncommon to have what is known as flaming take place in compressed air ports, pipes and passages. A candle will burn in a closed air receiver containing compressed air more violently than in the free air. If while burning this candle flame comes in contact with inflammable gases mixed with the air there will be what is known as flaming. What takes place in the automobile cylinder might really be called flaming, but the point to consider in compressed air plants is that, as with the automobile cylinder, this may do no damage provided the parts and passages are strong enough. If, however, this flaming is something more than what takes place in the automobile cylinder, because there is present in the air a sufficient amount of carbon to produce a violent explosion, then the condition becomes serious.

Take gun powder, for instance. We have a solid, which contains the elements necessary to combustion intimately commingled and ignition produces explosion. This combustion takes place so rapidly that we have a real explosion, and not a mere flaming or expansion as in the automobile cylinder. To continue the illustration let us suppose that we have a little dynamite in the place of the gunpowder. Here we have a still greater suddenness of combustion and a more violent explosion.

A piece of gun powder the size of a pea will produce one result, a quantity of gun powder the size of a cocoanut will produce another. Gun powder the size of a pea might be placed in the air pipe of a compressed air installation and ignite without doing any more damage than flaming, but a quantity of gun powder equal to the volume of a cocoanut would be certain destruction. The point to be considered here is that this carbon oil, or other material which collects in compressed air receivers, pipes and passages, if only there in small quqantities, might ignite without doing damage, but if it is neglected, allowed to accumulate, and a condition arises by which ignition takes place, we have a serious explosion.

The first point therefore, is to so build that there will be no chance through pockets to accumulate oil, carbon and other inflammable matter. Receivers, valves and passages should be looked into once a week and cleaned out. Do not clean them out in the easiest way; that is, by the use of kerosene, for this is adding fuel to the flames, but clean them out mechanically with a scraper.

No one can tell where or how an explosion of this kind originates. It is probable, however, that it comes from the air cylinder, either through a defective discharge valve, which might stick and allow the receiver air to come back again hot into the cylinder and thus pile up too great a temperature, or it arises from

a foreign substance being drawn in with the free air and through friction of the piston or valve resulting in a spark. This point is frequently neglected. We look at free air around an engine room and it looks all right, but it usually is not all right, and it should be cleaned by straining before it is allowed to go into an air compressor. There have been cases where the machinery has been completely destroyed in a few months through foreign substances, or even acids from furnace smoke, being drawn into the air cylinder, compressed and concentrated. Steam is clean, because it is distilled water, the foreign substances remaining in the boiler, and we frequently lose sight of the fact that because we have so little trouble in the steam cylinder we should not neglect the air end. Apart from the liability to destroy the piston, cylinder and valves, we are pumping down into a mine chamber dusty or foul air. The best air is that which comes from a well, and if a well is not available an artificial one can be built outside the engine room by putting some boards together, making a frame, and with the use of cheese-cloth, bagging or other cheap substance, baffle plates may be constructed and kept wet for catching at least the dust and dirt that is always in the air about an engine room. This also serves to lower the temperature, and it is certain that the cooler the air is when it goes into the cylinder of a compressor the more economical is the process of compression.

INERTIA OF AIR COMPRESSOR INTAKE

Fig. 1 shows an air-compressor indicator diagram with this rise in intake pressure above the atmosphere line at the end of the suction strokes, *A A;* such diagrams often being found and by some mistakenly regarded as evidence of discharge-valve leakage.

It is quite generally admitted that, under favorable conditions of unobstructed piping, high piston speed and relatively large number of reciprocations, a water pump actually will deliver more water than its piston displacement would indicate. This is simply because the water, attaining a high intake velocity, does not stop instantly when the piston reaches the end of its travel, but the inertia of the moving water tends to continue the flow during the instant of rest previous to reversal of piston stroke.

This sounds like "perpetual motion," but an instant's reflection will free the mind of such an impression. The speed and inertia given to the rapidly moving water must, of course, have come from the piston, and this latter must have received them from the power of the driving mechanism, so that every extra foot-gallon of work done will be accounted for at the motor end of the machine.

Such conditions in a water pump could obtain only with relatively low heads because, water being incompressible, the energy of flow quickly would be absorbed in overcoming the pumping head as the water rushed directly through the pump cylinder into the discharge. This restriction would not hold, however, with moving air for, although the air is very much lighter and has much less inertia for a given volume, even at its higher speed, this inrushing air would not encounter the pressure of the discharge at all; but simply would crowd into the cylinder against a pressure approximately atmospheric, causing a slight increase of this pressure above the atmospheric line, as shown in Fig. 1.

If the inertia effect does take place, as the rise in the air-intake line would seem to show, to marked degree sometimes, what effect does it have, and can any practical steps be taken to improve the action of a compressor thereby?

BASIS OF CALCULATION.

As a basis for calculating such an effect of inertia we may turn to the method of calculating the inertia forces of the reciprocating parts of a steam engine. We may do this on the assumption that the motion of the air in the intake pipe is in a series of pulsations corresponding to the reciprocating motion of the air piston. Close to the compressor cylinder, this probably is very nearly true and the effect must be similar in a gradually decreasing degree at greater distances. Even at the further end of a compressor intake pipe of considerable length, these pulsations are distinctly noticeable upon placing the hand in the current of air rushing into the pipe. Far enough away from the piston, the pulsation waves are, no doubt distinctly modified from the approximately simple-harmonic motion of the piston, but the distance would have to be very great before the elasticity of the incom-

ing air would be such as to absorb all pulsations and result in an even flow of air into the pipe.

Those who have studied the crank effort diagram of the steam engine, or other machine involving a crank and connecting rod, are aware that the starting and stopping forces at the ends of the strokes are, with an infinite connecting rod (or a "Scotch yoke"), equal to the centrifugal force that would be produced if all the reciprocating parts were revolving about the shaft at the radius of the crank circle. If the force at the end of the back stroke or beginning of the forward stroke, this force tending to produce tension in the rods, be considered positive; the stopping force at the other end of the stroke, tending to produce compression in the rods, must be considered negative.

At some time, then, during the stroke of the piston, the inertia forces must become zero, the parts having been completely accelerated and traveling along in equilibrium. With an infinite connecting rod (Scotch yoke), this point of zero inertia force occurs at mid-stroke, and a diagram of the forces of inertia of the parts would be as in Fig. 2. In this case, the forces at each dead center would be alike, and the point of zero force would be, as said, at mid-stroke.

In this reasoning the difference between *inertia* and *inertia force* must be distinctly appreciated. At mid-stroke the *inertia*, or stored energy would be maximum, due to the high velocity; but the *force* exerted would be zero, because there would be no acceleration or retardation. Toward the stroke ends, however, the slowing of the motion would transform the *inertia* into an active *force* pressing on the crank pin and assisting the motion, this force becoming a maximum just at the instant of stopping. At this instant, of course, the *inertia* would be zero. Whatever force assists the crank pin toward the end of each stroke, correspondingly tends to retard the crank pin during the start of the next stroke, so no net work is done by these forces.

EFFECT OF CONNECTING-ROD ANGULARITY.

For the real conditions of a finite connecting rod, we may refer to some calculations by Professor Jacobus in the Transactions of the American Society of Mechanical Engineers, Volume 11, pages 492 and 1134. In these

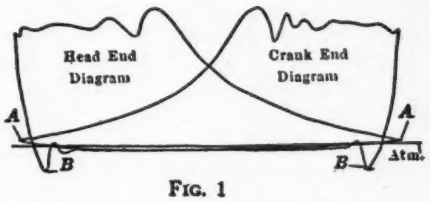


FIG. 1

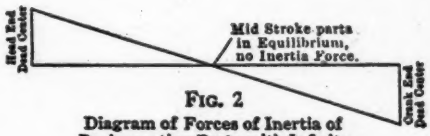


FIG. 2

Diagram of Forces of Inertia of Reciprocating Parts with Infinite Connecting Rod or Scotch Yoke.

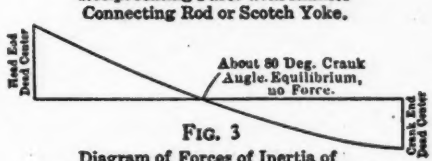


FIG. 3

Diagram of Forces of Inertia of Reciprocating Parts with Connecting Rod Length of 5 times the Crank Arm.

American Machinist

AIR INTAKE DIAGRAMS

papers will be found a table of factors worked out, by which the theoretical, infinite-rod forces may be multiplied to obtain the actual, finite-rod forces. A plot of such a calculation will produce a curve like Fig. 3, where the forces at the two ends of the stroke are unlike and where the zero point is somewhere around 80 degrees of crank angle, measured from the head center. These changes are due simply to the effect of the connecting-rod angularity in putting the piston forward of where it would be at any one time if the rod were infinite and had no angularity.

For an infinite rod, the force of inertia, in pounds, at any position of crank angle is expressed as follows:

$$F = \frac{W \pi^2 N^2 R}{900\, g} \cos. \theta,$$

where

W = Weight of reciprocating parts, in pounds;

N = Number of revolutions of crank per minute;

R = Crank radius, in feet;

g = Acceleration of gravity, 32.2;

θ = Crank angle, measured from head dead center.

When $\theta = 0$, $\cos. \theta = 1$ and F becomes the same as the centrifugal force, as already explained, for the dead-center position.

From Professor Jacobus' figures, for a machine having a connecting rod of length equal to five times the crank arm, the usual design for air compressors, the force at beginning or end of either stroke, should be

$$F = \frac{W \pi^2 N^2 R}{900\, g} (cos.\, \theta + 0.2).$$

APPLICATION TO MOVING COLUMN OF AIR.

To apply this formula to a moving column of air in a pipe, W will be the weight of air in motion, N will be the number of double reciprocations corresponding to the revolutions of the compressor crank, but the value of R will not be the crank radius. This will be understood from the fact that, due to the intake pipe being much smaller in area than the air cylinder, the air in this pipe must travel faster and further at each stroke than the piston does. Suppose the intake pipe area is approximately 12 per cent., or ⅛ of the piston area. Then, at any given time, the air must be traveling 8 times as fast as the piston and, in order to fill the cylinder, the requisite air will have to travel 8 times as far in the pipe as the piston does in the cylinder. In other words, the air pulsations are 8 times as long as the piston stroke, and consequently, in this case the value of R in the formula for the air must be 8 times the length of the compressor crank arm.

As might be expected, the formula shows that the inertia force is proportional to the square of the number of revolutions. This means that the greater the number of stops and starts in a given time, the greater the forces. Consequently a relatively short stroke with a given piston speed is conducive to heavy forces.

AN EXAMPLE.

To take a specific example: Suppose we have a 36-inch stroke air compressor, running at a speed of 100 revolutions per minute, a practical figure for modern, high-speed practice, especially for direct-connected electric drive with motor on compressor shaft. Let the cylinder be 34 inches diameter and let its average net area be 900 square inches. The intake pipe area, being ⅛ of this, let its inside diameter be 12 inches, with actual area of 113 square inches. The ratio of cylinder and pipe areas then will be 8 to 1, and so the air speed and length of air pulsation will be 8 times as great as those of the piston.

Let us say that the intake pipe is 25 feet long, from entrance at outside of building to cylinder; let the temperature of the air be 60 degrees Fahrenheit. At the instant of piston stoppage, the air in the inner end of the pipe will be compressed by the inertia to some pressure above the atmosphere, while that at the outer end will be atmospheric, and only that in the middle section will be, say, half a pound below atmosphere. It then will be reasonable to assume that the average pressure of all the air is atmospheric at the instant of stoppage and greatest force and pressure. The weight of the air contained in the pipe then must be 0.0764 pounds per cubic foot, and as the volume of the pipe of 12 inches inside diameter and 25 feet length is 19.6 cubic feet, the total weight of air flowing in the pipe at this instant will be 1.50 pounds.

Taking first, the force at the head center, we have, by applying the formula already given for a five-crank length connecting rod;

$$F = \frac{1.50\, \pi^2\, 100^2 \times 1.5 \times 8 \times 1.2}{900\, g}.$$

In this expression, the factor 1.5 is, of course, the crank circle radius in feet, and the factor 8 is the ratio of cylinder area to intake pipe area and, consequently, the ratio of air pulsation length to piston stroke; so that the product of these two factors represents the imaginary length of crank arm that would produce the air pulsations occurring in the intake pipe. The factor 1.2 is the sum of the cosine of 0 degrees (unity), the crank angle at head dead center, and the factor 0.2, calculated by Professor Jacobus for the connecting-rod length chosen.

The solution of the expression given above is:

$$F = 73.5 \text{ pounds.}$$

INERTIA FORCES DUE TO RECIPROCATION.

This is the total pressure exerted in stopping the column of air at the end of the suction stroke at the head dead center, but it must be remembered that, if the air passage is continuously of the same area, 113 square inches, this pressure will be distributed over this whole area and so the pressure per square inch exerted will be $\frac{73.5}{113} = 0.650$, or over ⅝ of a pound.

CUMULATIVE EFFECT.

Just at this point we should consider a further inertia effect; the "piling up" and compressing of the air in the cylinder and the inner portion of the intake pipe. The result of such an action would be to allow the remainder of the air in the pipe to continue flowing and crowding in, so that the actual length of air pulsation is greater than we have assumed. The effect of increasing this pulsation length is to increase the value of R in the formula, and thus further increase the force which we are endeavoring to calculate. The logic is that, the number of pulsations per minute remaining the same, the stopping force must be greater if the distance traveled, and consequently the linear speed, is greater; also the additional air entering the pipe adds its inertia to the effect.

As this would tend further to increase the pressure, let us assume that the final pressure would be, say 0.7 pound above atmosphere, or 15.4 pounds absolute. Now, the volume of the compressing cylinder is 18.7 cubic feet and, as an estimate, we may include the last 6 feet of intake pipe in this "piling up" effect. This gives a total volume of 23.4 cubic feet into which the incoming air is crowded from an initial pressure of 14.7 to 15.4 pounds. Then this 23.4 cubic feet of air will occupy a space

$$\text{of } 23.4 \times \frac{14.7}{15.4} = 22.3 \text{ cubic feet,}$$

thus leaving $23.4 - 22.3 = 1.1$ cubic feet of the last part of the pipe for more air to crowd into. With a 12-inch intake pipe this means a length of 1.4 feet, and this length is to be added to the value of R, or imaginary radius of pulsation wave. As the old value of R was $8 \times 1\frac{1}{2} = 12$, we now have 13.4 feet for the more probable value of R.

As the value of F is directly proportional to R, the more probable value of F now will be

$$0.650 \times \frac{13.4}{12} = 0.726 \textit{ pounds,}$$

giving a final intake air pressure of over 15.4 pounds per square inch absolute, which agrees with our assumption when we began to consider this "piling up" effect. It is, therefore, reasonable to assume that there would be, under the circumstances of this case, an initial air pressure just at commencement of compression, of 0.726, or nearly ¾ of a pound above atmosphere. This would increase the volumetric efficiency by quite 5 per cent., a result well worth striving for.

FORCES UNEQUAL AT HEAD AND CRANK.

At the crank end of the stroke, the force would be somewhat less, as the value of *cos.* θ would be — 1, and $-1 \times 0.2 = -0.8$. This would then make the pressure at the crank end about 0.484, or a little less than ½ pound per square inch above atmosphere, increasing the volumetric efficiency at this end by over 3 per cent. The average efficiency increase for the two ends then would range about 4 per cent.

This condition of unequal effects at the two ends is borne out in practice, for an examination of the indicator diagrams containing these inertia effects invariably shows more initial pressure at one end than at the other.

To be strictly logical, the increased quantity of air admitted to the outer end of the pipe by the crowding and compressing of that at the inner end, should be taken into account. This increase was shown to be 1.1 cubic feet, bringing the weight up to 1.58 pounds. This would further increase the head end inertia force to

$$\frac{1.58}{1.5} \times 0.726 = 0.765 \text{ pound per square inch,}$$

or over ¾ of a pound pressure; and the crank-end force to 0.51, or over ½ pound per square inch. This would tend to show that we are at least on the conservative side, leaving room for pipe friction and other losses.

PRACTICAL CONSIDERATIONS.

From the foregoing, it would appear that a longer intake pipe would contain more air in motion, and so would give an increased inertia force and higher volumetric efficiency. Double the length of pipe would give double the weight of air; but, as before intimated, the pulsations probably are modified considerably at the end of so long a pipe. Another matter too, is the loss of pressure by friction through this long pipe, but this is really negligible if the air speed is kept down around 4,800 feet per minute. As an example, tables worked out in Kent, from B. F. Sturtevant Company's formulas, show that the loss of pressure through 25 feet of 12-inch pipe, with a speed of 4,800 feet per minute, is about ½ ounce.

It may well be asked "why should the pipe produce this inertia effect any more than if the air flowed directly from the atmosphere into the cylinder, thus avoiding even the small friction of flow. The answer is that the air in the pipe has a smooth flow and has an opportunity to attain the velocity calculated; whereas, if the pipe were absent, the atmospheric air would flow from all sides at low speed and furthermore, all energy of motion would be lost in eddying at entrance. The pipe keeps the air flowing straight, swiftly and without eddying to any great extent.

Some persons will realize that this force or pressure required to stop the incoming air at the end of the stroke must be balanced by an equal and opposite inertia force required to *start* the pulsation at the beginning of the stroke. No better evidence of this can be desired than the ever present "hooks" *B B*, Fig. 1, on all air-compressor indicator diagrams. Two excuses usually are given for these; inertia of indicator parts dropping from the pressure of discharge to that of intake, and the pressure required to open poppet valves. The first excuse seems inadequate with a modern, light indicator and as to valve resistance, the writer has seen these "hooks" with Corliss inlet valves open wide before the stroke started.

It will be well to add that an actual case of this kind; but which, owing to several elbows and a strainer in the intake pipe, it was impossible to figure upon intelligently; recently has been brought to the writer's attention, where the initial pressure of the intake line is about 1½ pounds above atmosphere at one end and 1 pound at the other.

COMPRESSED AIR FOR SHAFT SINKING IN QUICKSAND

By P. B. McDonald.

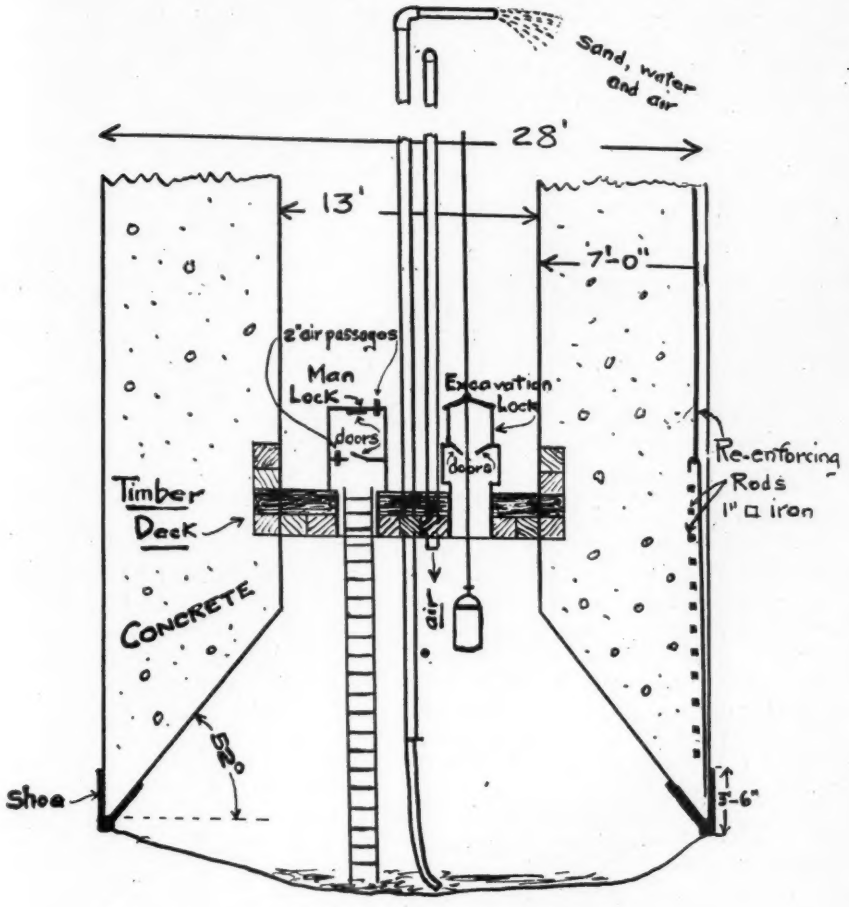
In the past few years a number of reinforced concrete shafts through quicksand and soft soil have been sunk for iron mining companies of the Lake Superior district by the Foundation Co. of New York. The Cleveland-Cliffs Iron Co., which, by the way, has introduced several desirable reforms into the mining business, was among the first to recognize the possibilities of the compressed air method for shaft sinking and to apply the proved devices of bridge pier, tunnel and building foundation work to mining. Their Smith and Kidder shafts on the Swanzy range, sunk in 1907 and 1908 by the Foundation Co., were in a way innovations to the mining men of the district, and established a precedent that has since spread to the Marquette, Menominee, Mesaba, Vermillion and Cuyuna ranges.

In principle the method is as follows: A vertical, hollow cylinder of concrete is constructed on the surface with a steel shoe on the pointed, cutting edge. The earth is excavated from the inside and the caisson sinks of its own weight. It is kept plumb by digging out under the high side. More concrete is added at the surface in 5-ft. sections and the sinking goes on until ledge is struck, when the steel shoe is sealed to the solid rock so as to make a tight joint. In going through quicksand air locks are put on the top, and compdessed air is forced into the caisson to hold back the sand and water, which would otherwise fill the shaft.

First taking up the process in ordinary soft ground where compressed air is not necessary, it is recalled that the method is by no means a new one, but has been used considerably in Germany, where the caissons were constructed of stone or brick. But neither of these materials can be compared to concrete, which combines weight with strength to form an almost ideal material.

In shape the caisson may be rectangular, eliptical or circular. The type which is used in the iron country is circular on the outside and may be circular or rectangular inside; the sketch shows the latter case. In the caisson, circular both inside and out, the thickness varies from the bottom up. In other words, with the pressure. Thus one shaft was made 3 ft. thick at the bottom and 1 ft. 6 in. at the top.

A clam shell, or a regulation contractor's derrick, is used in the excavation when there is enough water to make the ground safe, and water up to this limit is desirable. However, much of the excavation has to be done by men shovelling into a bucket, especially where boulders interfere with the equal sinking of the caisson. It is sometimes necessary to apply additional weight to sink the structure. and wet sand and pig iron have been used for this purpose. Blasting is sometimes resorted to, even when the compressed air is on, and not uncommonly the ledge dips at such an angle that it is necessary to blast it down to a level



SHAFT SINKING IN QUICKSAND.

surface in order to properly seal the caisson. Or, if the rock is oxidized and crumbly at the surface, it has to be broken down to a solid foundation.

The steel shoe is made in four sections of 90 degrees each, which are riveted together on the ground. The sides of the shoe are ½ in. steel plate, and they are held together by cross pieces of ½ in. web plates placed about 4 ft. apart all around the circle. The shoe is left open at the top and concrete is filled into it.

The concrete is built up in 5 ft. sections. The outside forms are curved steel plates in sections of 90 degrees; the inside form is a wooden frame that is carried up as the caisson sinks, or the inside forms may be steel also.

When compressed air is used the problem becomes more complicated and more costly. A heavy deck of timber or steel is fitted into a recess in the wall and is calked tight. Two apertures are left in the deck, over each of which a steel cylinder about 4 ft. in diameter is placed. One cylinder is a man lock and the other is an excavation lock, through which the dirt is hoisted out. The deck may also admit an air pipe for blowing air into the shaft, and a blow pipe through which a mixture of sand, water and air is blown out by the pressure inside, thus assisting the excavating work.

The doors of the excavation lock are controlled from the outside. After the bucket has been pulled through them they are closed and the bucket is hoisted, carrying the cover of the lock with it on a buffer. When the buffer is lowered again the top is bolted back into place,

the doors are opened and the operation begins again. A stuffing box on the cover at the rope hole keeps the air from escaping.

The man lock, in addition to the two doors, has two 2 in. air passages controlled by valves to gradually change the pressure in the steel cylinder. The lower door and the 2 in. air passage are closed when men are admitted to the cylinder; then the upper door and the upper 2 in. air passage are closed and the lower air passage is slowly opened so that the pressure gradually rises to that in the caisson, when the men are allowed to climb down below. The process is reversed when the men are coming out.

This locking through of the men is time-taking and cannot be hurried. If sufficient time is not taken to accustom the ear drum to the pressure while going in the head rings with an almost unbearable pain. In coming out, if the men do not remain long enough in the lock they are seized with the "bends," a paralysis of the body and limbs that sends them shrieking to the "hospital" lock. This is a large steel cylinder, some 20 ft. long by 7 ft. in diameter, in which a high air pressure is maintained; when the men are inside this a small valve is opened and the pressure is allowed to fall very slowly until it becomes normal.

Five hundred dollars per foot is not an exorbitant cost for sinking through quicksand for the large sized shafts put down in the Lake Superior region.—*Mining Science.*

BOTTLE MAKING MACHINES

Mr. Leonard A. Kupferberg recently read before the Junior Institution of Engineers an interesting paper upon the Manufacture of Glass Bottles. Although machines for this purpose have been the subject of many inventions, it is only quite recently that they have been so perfected as to enable them to compete with manual labor.

The principle of all the machines so far invented is to cast a stick or bar in a mold, one end of which forms the mouthpiece of the bottle. A punch or pin is inserted through the mouthpiece part of the mold, thus partly hollowing the bar. The mold is then removed; a second one, with the full shape of the bottle, takes its place, and the tube is inflated into the desired shape. The glass, in most of the machines mentioned, is filled into the tube-mold by manual labor, that is to say with a scoop.

Cast iron is usually the material from which the molds are made. The bottles supply enough heat to the molds to prevent their being cooled too quickly. The pressure required in bottle machines varies, according to the glass used, from 10 to 30 lbs., per sq. in.

By far the most ingenious is the Owens' machine, having six sets of molds fixed to a frame revolving on a vertical axis. A small ante-chamber, the base of which is formed by a revolving fire-proof clay tub, is attached to the furnace. The latter supplies the revolving tub with glass, the object of its motion being to constantly supply new glass to the machine.

Separate burners are arranged round the chamber for the purpose of maintaining the temperature of the glass in the tub. On one side of the chamber the tub projects several inches, and into this the end of each one of the tube molds is dipped, and is there filled by suction. During the revolution of the frame the various stages of formation (the replacement of the molds, the inflation, etc.) are gone through, and shortly before a mold re-arrives at the tub, it opens and deposits its bottle, bottom upwards, into a funnel, through which the bottle slides to a small stove for the so-called "fire-finish." In the stove, it is exposed to a high temperature, which brings the glass near the melting-point, thereby removing any tension in the neck or mouthpiece caused by the insertion of the cold pin in the beginning of its formation. Six sets of molds are fixed to the revolving frame, each revolution of the latter therefore producing six bottles. On leaving the "fire-finish" stove the bottles are placed in the annealing stove.

The Owens' machine turns out 14,000 to 16,000 bottles per 24 hours. Twelve of these machines are now in satisfactory use in Europe.

Inflating hand-made bottles by mechanically compressed air has frequently been tried, but always with indifferent success. The even distribution of the glass in the walls of the bottle largely depends on the pressure used, and this can be adjusted evenly by the lungs, but not so by the means of mechanically compressed air.

TURBO AUXILIARIES TO PISTON COMPRESSORS

As works and industrial establishments grow in size, it is often a very difficult matter to know what it is best to do in order to keep the plant up to the capacity that will adequately fulfil the demands which are made upon it. In the early days of an establishment the power may have been ample, but with the passage of time it is gradually borne in upon the minds of the owners that something will have to be done if their output is not to be very seriously handicapped. There are more ways than one of doing this, and probably two of the ways are to erect entirely new plants, and do away with the old plant when the new is ready for work, or to add new plant to the old, so that, when run together, the latter may receive the help it requires. The cost of either of these methods is often much more than would have been the case had the additional power been installed at first, and the decision as to which offers the more favorable prospect for the future is one that frequently requires no little experience, because many other things than actual first cost may have to be considered.

A case of the kind recently arose at an English colliery, where, in order to meet the increased demand for air, either the existing piston-compressor plant—a cross-compound engine with cylinders 28 in. and 50 in. diameter, by 60 in. stroke, driving duplex air cylinders of 33 in. diameter, running up to from 30 to 35 revolutions per minute as a maximum—could be augmented by a similar set, or, with a view of increased efficiency on the air cylinders, by the installation of a compound two-stage compressor, or finally by the adoption of a turbo-compressor set receiving its driving energy from the exhaust (at about atmospheric pressure) of the low pressure steam cylinder. Here the plan contemplated was that the turbo-compressor should pass its discharge through an inter-cooler into the existing air cylinders. It was found that the cost of the second complete piston compressor would very much exceed the first cost of the turbo-compressor installation, and it would also require much more floor space; moreover, a gain of efficiency could be obtained only with the new piston compressor plant, whereas the turbo-compressor would improve the working efficiency over the whole combined capacity. For these reasons, therefore, it was decided to install the turbo-compressor. The results have fully justified this decision, a gain of about 17 per cent. over what would have been secured from a second piston compressor having been obtained.

The turbo-compressor is of the Rateau type, and was subjected to tests which proved that the guarantees were fully realized, easily delivering from 6,000 to 7,000 cubic feet of free air per minute at 12.8 lb. gage. The steam consumption claimed for the turbine also was established. The flexibility of the plant was particularly noteworthy, as outputs up to 12,000 cu. ft. per min., and pressures up to 16 lb. were easily realized.

When running the existing piston compressor at the normal speed of 30 revolutions per minute, taking in air at atmospheric pressure and temperature, the maximum volume discharged at 60 lb. was 3,000 cu. ft. of free air per minute, while with the addition of the turbo-compressor set, with the piston compressor at the same speed as before, an increase in the free air capacity of over 100 per cent. was obtained, and the total efficiency both of the air and of the steam was greatly improved.

The low pressure steam cylinder of the existing duplex piston compressor now discharges into a large steam receiver—an old boiler shell with automatic relief valve arranged to prevent undue accumulation of pressure. From this the steam passes through the exhaust steam turbine to the condenser arranged underneath the turbine exhaust branch. The turbine is absolutely under the control of the reciprocating compressor, as a demand for more work from the plant requires more steam from the duplex compressor, and provides the turbine with the necessary steam for the required air capacity or pressure.

The Rateau turbine is of the multicellular type, the cylinder of which is divided into a number of compartments, in each of which are fixed the distributing vanes. It is of the "Action" type, the fall of pressure taking place in the distributors only, the expansion being utilized to create kinetic energy. As the pressure is the same on both sides of the moving wheels, balancing pistons are not required as in "reaction" turbines, where the fall of pressure takes place partly in the moving wheels. A Rateau type of centrifugal multi-stage blower is also used. Diaphrams are placed between the wheels and take the air at the outlet of each wheel and lead it through channels of

special shape into the eye of the next wheel after having transformed the velocity head into pressure head.

From the very satisfactory results given by this installation it is believed that there will be a wide field for the application of turbo-compressors both for increasing the output of existing plants and materially augmenting the economy. It is also expected that they will prove very suitable for separate new plants, owing to the wide range of capacity and pressure that they possess, in addition to their high efficiency.

BACTERIA

Many seem to regard germs as minute animals, others seem to consider them insects, and therefore often confuse the scope of bacteriology with that of entomology. Bacteria are really microscopical plants—they are the smallest of all living things. Indeed they are so minute that it is almost beyond our conception to think of life existing in such minute objects. The unit used in measuring bacteria is known as the micron, which is equal to 1:25,000 of an inch. The average diameter of bacteria is about one micron. It would require therefore 25,000 bacteria of the average dimensions placed side by side to measure an inch, or it would require about 2,000 of these to cover the point of a pin, or about 200,000 to completely cover it. In shape bacteria are of three general types—spherical, vod shape, and spiral form, and are accordingly divided into three general classes, known as coccaceae, spirrillacae, and bacillacae. Bacteria can be found almost everywhere in nature. As a general rule their function may be termed analytical, that is they are continually breaking down the higher forms into simpler forms of life. In the soil they liberate plant food from its unavailable state of highly complex matter and render it assimilable to the plants. They multiply by division, which under favorable conditions may take place every quarter of an hour. The parent cell, dividing once every hour which is not an exceptional case—would under favorable conditions produce a progeny of 17,000,000 bacteria in 24 hours. From this it will be noted that in the bright lexicon of bacteria there is no such word as race suicide. Happily for man in his fight against harmful bacteria conditions are not often such in nature as to allow for this theoretical progeny.

DECOMPRESSION FOR COMPRESSED AIR WORKERS

A valuable paper on Caisson Sickness was read recently before the Royal Society of Arts by Mr. Leonard Erskine Hill, F. R. S., and the paper has been carefully abstracted by the *Engineer*, London. Our readers will be aware, it says, that it has been recognized for a long time now that the troubles experienced by men working under pressure are due to the fact that nitrogen is dissolved in the tissues of the body. When decompression occurs suddenly, or more or less quickly, this nitrogen cannot escape sufficiently quickly, and bubbles of it make their appearance in the blood and interfere with the circulation. We need only quote one form of disease produced as an example. The paralysis known as diver's palsy is due to a local death and degeneration of the spinal cord brought on by bubbles of nitrogen blocking the circulation there. The question has been well studied both in this country and abroad, and it was early recognized that the harm did not lie in actually being submitted to pressures higher than that of the atmosphere, but in this pressure being too suddenly relieved. Accordingly it has been customary in diving and other operations necessitating the use of high pressures to arrange for a graduated rate of decompression varying with the pressure employed. In a book on the subject published in Germany in 1900, Messrs. Von Schrötter, Heller and Mager laid down the principle that a uniform decompression rate of two minutes for each .1 of an atmosphere; or, in other words, twenty minutes for each 15 lb. pressure was safe. They based the calculations by which they arrived at this conclusion on the law of saturation and desaturation of the body, which had been enunciated by Zuntz. Up till comparatively recently the whole idea has been to decompress slowly but continuously, and in cases of high pressure the period of decompression has necessarily been lengthy. In a lecture which Mr. Hill gave at the Olympia Exhibition in October, 1907, he expressed himself as believing in steady and uniform decompression. In his recent paper he shows that he has reason to believe that what is known as stage or step decompression is to all intents and purposes as good and as little injurious, and, moreover, that it saves time.

It was, we believe, Dr. John Haldane who

first advocated step decompression.* He proposed that supposing a diver were working under a pressure of six atmospheres, in decompression he should be quickly brought up to a point where the pressure was only from 1½ to 2 atmospheres; that he should remain there from thirty to sixty minutes and then be brought quickly to the surface. The idea was not immediately universally adopted; indeed, there are doubtless many who still adhere to the principle of gradual but continuous decompression.

By no means the least valuable portion of Mr. Hill's present paper is that which is devoted to the numerous experiments which he, in collaboration with others, have carried out regarding the effects on the human body of various methods of decompression. It would be impossible with the space at our command to go in detail into these experiments. They were, however, evidently carried out with great care, and by means of an old steel boiler with a cubic capacity of 42.2 cubic feet. In this either Mr. Hill or his co-worker, Mr. M. Greenwood, were exposed many times to pressures exceeding + 60 lb., four times to + 75 lb., and on one occasion Mr. Greenwood underwent a pressure of +92 lb.—this, we may mention, being equivalent to immersion in water to a depth of over 210 ft. They investigated the effect of various methods of decompression by analyses of urine passed under different pressures and circumstances, arguing that when the kidney is actively secreting, the saturation of the urine with nitrogen gas must approximate to that of the arterial blood. They also experimented with various animals, including goats and pigs.

The conclusions which they reached were, first, that it is safe for a man to be rapidly decompressed after exposure to about + 18 lb.; this, it may be added, is the general experience in caisson working. Then the investigations led to the opinion that a stage at + 8 lb. lasting fifteen minutes is enough after a shift at + 30 lb., and a stage of thirty minutes at + 15 lb. after a shift at + 40 lb. to + 45 lb., provided a medical lock for recompression is at hand. Recompression in case of adverse symptoms after too rapid decompression was found to be of much value; but evidently Mr. Hill thinks that expert medical advice should be available in any works where high pressures are employed.

The final opinion at which Mr. Hill appears to have arrived is that whereas decompression times are often too short, those tabulated by the Admiralty Committee are unnecessarily long, particularly if the men are persuaded to exercise their bodies during decompression. This committee, by means of experiments on goats, found a great superiority of the stage over the uniform method of twenty minutes per atmosphere, and drew up a set of tables which give times of decompression with a great appearance of exactitude. The tables were, however, based on theoretical assumptions as to circulation time, volume of blood, and desaturation of the blood in its passage through the lungs. Mr. Hill points out that as bodily activity has a most potent effect on the circulation, increasing the rate perhaps six or ten times, and converting "slow" parts into "quick" parts it seems clear that these tables have only a limited accuracy. Moreover, he asserts that the statement that the blood is desaturated in its passage through the lung requires proof. Hence, having personally found the benefit of bodily exercise during decompression he advocates it most strongly, averring that not only may decompression time be reduced by its means, but that the chances of harmful consequences are reduced. If, for example, men coming out of a caisson could be made to climb up to the top of the shaft and down again during the time they are waiting for the end of the stage it would greatly increase their safety. Experiments made with the breathing of oxygen immediately prior to decompression have indicated that such a proceeding would also tend in the direction of protecting the workmen from ill effects, especially if bodily exercise be indulged in during the compression. With the two combined Mr. Hill thinks the time of decompression might be shortened. Further investigations, however, are necessary before it can be determined by how much the time may be safely shortened.

The work of Mr. Hill and his *confrères* has undoubtedly carried our knowledge of the subject further than it was, and it is now pretty clearly known under what conditions men may work with safety under high pressures. The great thing is to see that they conform to the

*COMPRESSED AIR MAGAZINE, Vol. XIII, Page 5106.

necessary regulations, which they are by no means always ready to do. This is understandable. They are naturally anxious to be free after a spell of work. Much of the sickness experienced in the past has been due to wilful disregard of regulations. Anything, therefore, that can be discovered which will reduce the time necessary for decompression without increasing the risk must be beneficial, for the less time the men have to spend while the pressure is being removed the less likely are they to infringe the rules.

GAS CURE FOR WHOOPING COUGH

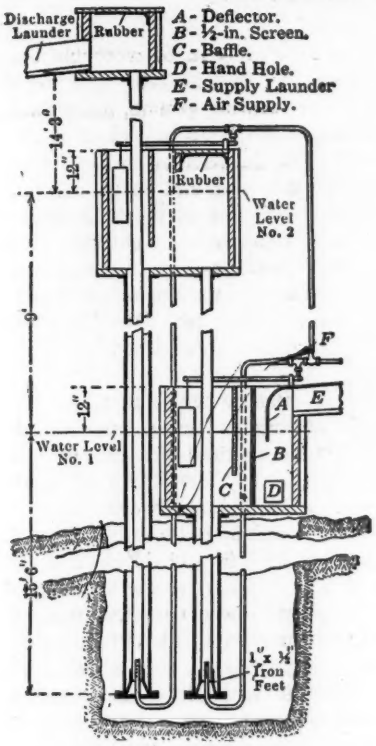
A Los Angeles, Cal., newspaper item states that from twenty to two hundred persons afflicted with whooping cough and similar throat troubles crowd into the purifier house of the local gas company every day and that two thousand cures have thus far been recorded. There was an epidemic of coughing in that city last month, and right valiantly the gas company came to the rescue and threw open its doors to the afflicted. The writer of the item attributes the cures to "naphthaline fumes," and thus explains their origin: "The naphthaline is a by-product of the oxides of iron used to divert the sulphur from the gas." A sign might be hung over the door bearing the name "bronchial and pulmonary dispensary." Those who "cough up" at the cashier's window in such agony might be sent to the "dispensary" to recuperate. Thus the querulous, the asthmatic and whooper shall gather together for the gas man to bestow upon them his blessing.—*Progressive Age.*

FROZEN DYNAMITE

Frozen dynamite is the subject of grave suspicion among most engineers, yet experts hold that it is far less sensitive than unfrozen dynamite. In order to prove this, Dr. Walter G. Hudson and Mr. E. J. Riederer, the latter superintendent of the Du Pont works at Lake Hopatcong, conducted some experiments on Feb. 24 that are decidedly interesting. They were made with a particularly sensitive grade of 60 per cent. gelatine dynamite and also with some straight dynamite. A number of these sticks were used as targets for bullets from a Krag-Jörgensen Government rifle, loaded for a velocity of 2150 ft. and fired at a distance of 50 ft. from the dynamite. The bullets discharged in this way failed in every case to explode the sticks of frozen, straight and gelatine dynamite. Other frozen sticks were then thawed and used as targets in precisely the same way. In every case the bullets detonated them, thus showing the decreased sensitiveness due to freezing. The same thing was shown in another way by using thawed sticks which were broken in two. If a cap with 30 gr. of fulminate of mercury was attached to half of a thawed stick and the other half was placed 8 in. from it, the latter would be exploded when the former was fired. If, however, a whole stick of frozen dynamite was placed 8 in. from a half stick of thawed dynamite and the latter was fired the frozen stick remained unaffected. In fact it was not until the frozen material was placed within 1 in. of the piece fired by the cap that it could be exploded. When sticks of frozen and of thawed dynamite were blown into the air with black powder it was found that the former took about three times as long to burn as the latter. Tests of this character seem to prove that frozen dynamite is not sensitive, yet even when it has been benumbed by the cold it should be handled with great care. It is best not to become familiar and careless with anything of such a violent temperament.

EXCESS CHANGES CONDITIONS

In fast steamers resistance does not increase with the cube of the speed, and there are certain higher critical speeds at which resistance is less. Nearly 100 years ago in England a man running express passenger canal boats had them towed by galloping horses at a speed of nearly 14 miles an hour, claiming this was easier than a slower speed. He was ridiculed by scientists who opposed the law of cubic increase of resistance. A bet was made, dynamometers attached, and up to 8 miles the law held good; but above 8 miles the canal boat began to climb out of the water, so that at 14 miles the actual resistance was small. This was the origin of the hydroplane boat. A wise Kansas mare hitched to a plow, if it pulled heavily, would look back, take in the situation, and increase her speed. The plow immediately pulled easier because the greater speed flung the clinging earth free of the mold board, thus greatly lessening friction.—*Harrington Emerson.*



AIR LIFT FOR TRANSPORTING SAND

An application of the Pohle air lift to raising and transporting the sand from cyanide tanks was recently made at Burbanks Main Lode mine in West Australia. The sand had to be carried across a public road, requiring a lift of 23 ft. 3 in. It was decided that a submergence of 63 per cent. of the total length of water pipe was required, which in a single-stage lift would have required a pit 39 ft. 6 in. deep. For this reason a two-stage lift was adopted, reducing the depth of pit required to 15 ft. 6 in.

The air supply for each lift is regulated by floats, so that a nearly constant level is maintained in each head box, and no air is blown to waste. The two lifts combined use 47 cu. ft. per min. of air; discharge 320 lb. sand per min., and require 800 lb. water per minute. This means 6.8 lb. sand are discharged per cu. ft. of air. The air used was drawn from a large receiver. In testing the air lift, this receiver was filled to a gage pressure of 70 lb. per sq. in., and was then shut off from the compressor, and the fall in pressure in a given time noted. During this time no air was drawn from the receiver for any other purpose. Mine water was used for sluicing, and the amount available was only little more than sufficient to carry away (along a V-shaped launder having a fall of ⅞ in. per ft.) as much sand as one man could shovel into the discharge door of the vat. The sand is heavy, and rapid motion is necessary throughout to prevent it settling; the proportion of water to sand is about 2½ to 1.

SAND FORMERLY SHOVELED

Before the air lift was put in, it was the practice to shovel the sand through the bottom discharge doors into trucks; with the air lift one man empties the vat in considerably less time than two did with the trucks, no time having to be lost in changing and waiting for trucks. The vats hold 30 long tons and, with one man shoveling, they are emptied in 3½ hours, using 45 to 47 cu. ft. of free air per minute. Each discharge door has a 4-in. socket screwed into it, and the door is never removed. From the bottom of the socket a pipe leads down vertically with an elbow just above the launder; inside the vat a pipe is screwed into the top of the socket long enough to reach above the top edge of the vat. To discharge the vat the pipe projecting through the sand is unscrewed and pulled out, leaving a convenient hole through which to start sluicing. To avoid the risk of having more sand sluiced into the launder than the water is able to carry along, from 25 to 30 per cent. of the total added water is supplied to the highest end of the launder running under the discharge doors.

Both sections of the lift are of the same dimensions, except in hight, and consist of a 6-in. cast-iron pipe (which constitutes the well) with a 3-in. wrought-iron pipe inside, extending from within four inches of the closed bottom end of the 6-in. pipe, up to the required hight of lift. The air pipes are ¾ in., though ½ in. would be ample; they are carried down the pit outside the 6-in. pipes, and are turned up at the bottom through the center of the dead end of the bottom of the 6-in. pipes. They extend upward for 10 in. in the 6-in. and for 6 in. in the 3-in. pipes. The nozzle ends of the air pipes are closed and twelve hacksaw slits are cut across each of the ends, the cuts extending round about one-quarter of the circumference of the ¾-in. pipe and cut at

an angle of 45 deg., thus giving the air an upward direction.

The lift has worked well from the start and has caused no trouble or delay. When the water supply fails a ½-in. water pipe (which is kept connected by flexible hose to a supply having a pressure of about 50 lb. per sq. in.) is passed down the 6-in. pipe which is cleared almost as fast as the ½-in. pipe can be lowered. Two or three minutes is sufficient to clear it at any time. The only wearing parts are the 3-in pipes, and these, having no bends, are likely to last a long time. The consumption of air may be taken as about 50 per cent. more than the best pump would use when in perfect condition. Unlike sand pumps the air lift remains in perfect condition.

The added water is heated to a temperature of 95 deg. F. by passing a part of it over exhaust-steam pipes on its way to the lift. This heat, no doubt, adds to the efficiency of the lift.

AIR DRIVEN CORE DRILL IN A ZINC MINE

By Frank W. Sansom.

Joplin, Mo., has always been a field into which manufacturers and operators of core drills have hesitated to enter. Several attempts have been made to utilize the diamond drill, but they were apparently unsuccessful. The principal difficulties seem to have been encountered in drilling through pockets and crevices, in which the diamonds were likely to be torn out and lost.

The shot drill was tried in this district several years ago apparently with no better success, the principal difficulty being that the drill could make almost no headway in some of the hard flint encountered. There are no authentic records available regarding these attempts, but they must have been discouraging, or later attempts would certainly have been made.

CHURN DRILLING USED IN THE PAST.

The churn drill is widely used, and is satisfactory from a mere drilling standpoint, but the records obtained are not reliable. Many good mining properties have been condemned, and many poor ones recommended on data obtained by churn drills.

The drilling is almost always done by contract; speed is about the only factor considered; and the holes are not cleaned thoroughly nor often enough, so a thin rich stratum often appears as 4 or 5 ft. of workable ore. This would not be so misleading but for the fact that the ore-bearing ground, being much softer than the rock above or below, is cut much easier, so the diameter of the hole at this point is greatly enlarged, and shows more ore than it should. The jar of the tools and wash of the water also tends to enlarge the hole at these rich places, and the mineral runs down to greater depths, making a false and misleading record. With a core drill this is impossible as the cuttings are not depended upon for the record.

USE OF THE CORE DRILL.

The objections above noted, and many others, made the need of a core drill very real and imperative. The improved methods of prospecting, and the growing desire among progressive and uptodate operators more thoroughly to exploit and block out their ore bodies, will doubtless create a further demand for better and more extensive drilling.

Since a majority of the mines in the district are working in deeper hard-ground orebodies, the principal difficulties with which the core drill will have to contend are the extremely hard rock here encountered; crevices, open and mud pockets, shelly flint, etc. It is probable also that the difficulty of overcoming local prejudice against new methods and machinery, and the increased cost of drilling, will be no small problem.

INTRODUCTION OF THE CORE DRILL.

As a bit of history it is pertinent to mention here the events that led up to the introduction of the core drill by this company. About a year ago they introduced an innovation in churn drilling. Their present workings are at a depth of 240 ft., but an old deep drill hole showed ore to a depth of 300 ft. The management conceived the idea of installing a drill underground, in order to save a depth of 240 ft. of drilling and the attempt was entirely successful. Three holes were drilled, showing workable ore to a depth of 300 ft. The problem of sinking the company's shafts to such an increased depth, and the expense attending the opening of new workings was such an important one, that it was thought best to try to secure more accurate information regarding the deeper run of ore before attempting extensive operations.

The ground drilled was limestone and flint, and seemed to offer no theoretical obstacles

to core drilling, other than extremely hard rock, and occasional small pockets. These the company was satisfied could be surmounted by the core drill, so they purchased from the Ingersoll Rand Company a Davis-Calyx class F-1 shot drill. The drill bores a hole 4¼ in. in diameter, makes a 3¼-in. core and has a depth capacity of 800 ft. A drilling expert was sent to install the drill and train a local crew to operate it.

The drill was lowered into the ground and set up without difficulty, and, contrary to all prophecies concerning this drill, and the usual delays encountered in installing machinery under new conditions, it started without trouble. The driving engine was first operated by steam but later by compressed air, and ran perfectly with either.

Five holes have been completed to date, the first to a depth of 90 ft. from the floor of the mine, or 330 ft. from the surface. The others were drilled to an average depth of 300 ft. The drill is now operating on the sixth hole.

CHARACTER OF GROUND DISCLOSED.

The character of the strata penetrated was white, gray, and brown limestone, white, blue, and black flint, varying in hardness in the order named, the limestone being the softest, and the black flint the hardest; all of the rock being similar in character to that found on the 240-ft. level of the mine. The black flint in this formation is reputed by all men who have worked in this mine to be as hard or harder to cut with the rock drill than any rock in the entire district. The hardest materials encountered by the core drill were balls or nodules of blue and black flint bedded in the limestone.

Zinc blende, or jack, was the only ore found. It occurred in pockets and horizontal seams from one to six inches in thickness; vertical and inclined fissures; and disseminated through the limestone and flint. The only unusual occurrence noted was that disseminated through the limestone, something unknown in the upper workings of the mine, and rarely found anywhere in the Joplin district.

CHARACTER OF CORES.

The cores varied in length up to 30 in., the average being about six or eight inches. The broken nature of the cores was due to the numerous cracks and fissures in the rock. No difficulty was encountered in picking up the broken pices of core, as they readily worked into the core barrel, and were held there by the solid core coming immediately under them. One of the principal objections to the shot drill for this district was in drilling through pockets, in which case it was predicted the shot could not be kept under the bit, hence the drill would not cut. A number of pockets were drilled through, some as much as a foot and a half in depth, and no serious difficulty was noted.

SPEED OF DRILLING.

The depth drilled per day of eight hours on the first hole varied from two to eight feet, averaging four feet; on the second hole the average was 5½ ft., on the third, fourth and fifth holes, six to seven ft. The best day's drilling on the first hole was eight ft., on the second 13ft., and on the last three holes 17 ft.; the character of the rock was about the same in each hole. The increased average on the various holes was doubtless due to the increased experience of the drilling crew, which became better acquainted with the performance of the drill as the work proceeded.

Of course the hard blue and black flint drilled very slowly, two or three feet per day while drilling in them exclusively, being a fair day's work; while drilling in limestone 15 ft. per day was easily made. One condition that prevented faster drilling was the frequency with which the cores had to be taken out. This was mainly due to the broken condition of the core. After the core barrel became partly filled with broken core, the pieces had a tendency to rotate on each other, thus grinding off the ends. The jack being comparatively soft was thus most easily ground and lost, so while drilling in ore-bearing ground it was necessary to draw the cores very frequently.

Another condition that took time was the comparatively low derricks used. The derrick on the first, second, fourth and fifth holes was 26 ft. high, allowing a break in the drill rods in drawing the tools, of 20 ft. On the third hole the derrick was only 21 ft. high, necessitating a break every 10 ft. The change of rods were 2, 5 and 10 ft., thus the time required for taking out cores consumed at least one-third of the working time of each shift.

THE COST OF DRILLING.

The cost of drilling is figured from the second, third, fourth and fifth holes; the first hole

being drilled by a highly paid expert, with two helpers who were learning the work. All the other holes were drilled by one drill-man and one helper. The labor cost on these last four holes was about 95c. per ft.; shot 15c. per ft.; bits, 10c. per ft.; power, repairs, etc., 10 to 15c. per ft., making a total cost per foot of $1.25 to $1.30. This seems to be a high cost when compared with churn drilling at 80c. to 90c. per ft., but when the reliability of records are compared it is considered, by this company at least, a satisfactory and economical investment.

METHOD OF KEEPING RECORDS.

The cores were kept in boxes five feet long holding two cores each, side by side, or 10 ft. of core. The pieces of core were tagged with consecutive numbers, and were thus recorded in the written log of the hole, in which the character of the rock, apparent value of the ore contents, depth, etc., were noted. For the purpose of finding the exact value of the ore, the cores containing ore were ground in a sample grinder, to a ½- or ¾-size, then quartered; one portion was powdered and assayed, the other returned to the core boxes for future records.

The performance of the drill for this company seems to demonstrate beyond question that the shot drill or core drill is eminently practicable for this district, at least in the hard-ground mines. The variety of ground encountered in these five holes, considering the crevices, pockets, and the extremely hard rock, seems to be a broad enough test to warrant the above conclusion.

Probably the best plan for using this drill in this district would be to drill a hole down to the ore horizon with a churn drill, casing the hole where necessary, and then take a core from the ore formation with the core drill. A combination churn- and core-drill rig, or two separate rigs operated in conjunction with each other, would make the drilling cost but little more than churn drilling. Two separate rigs would probably be better so that both could be in operation on different holes at the same time. In such a combination of the two methods of drilling advantage could be taken of the best features of both drills, the churn drill for speed in barren ground and the core drill for a reliable record in the ore formation. Now that the core drill has achieved such practical success in this test, it would seem only a question of time until it would be in common use in this mining district.—*Engineering and Mining Journal.*

GASOLINE FROM NATURAL GAS

Any gas from a sand from which oil is produced will yield a profitable amount of gasoline, ranging in gravity to 82 to 96 degrees. The gravity depends on the density of the gas and the extent to which it must be compressed to obtain best results.

The gas from Bradford sand oil wells is known to produce under present stage of development, from 2½ to 3½ gallons per 1,000 cubic feet under compression of 275 to 350 pounds. The gravity of this product is 86 to 94. Gas from the second or what is known as the Watsonville, Kinzua or Tiona sand yields a greater percentage of gasoline under lower pressure. This is due, so far as pressure is concerned, to the normal or natural rock pressure, which in this particular sand does not exceed 300 pounds, while the initial pressure of the Bradford sand runs as high as 600 pounds. The gravity of the oil in the different sands has some effect on the gas.

The second sand oil being lighter, more of its qualities that are rich in the hydrocarbons are absorbed and carried away in the gas. This may be fully demonstrated by letting the gas from a dry gas sand circulate through oil on its way to the point of consumption, where careful rotation will show, in increased efficiency, what the oils of different gravity contribute in heat units toward enrichment of the gas. Care must be observed in such tests to admit a proper amount of air to secure the best results in combustion.

Gas from the deep gas sands, where the initial pressure would reach 800 to 1,000 pounds, does not yield, under any known system, an appreciable quantity of gasoline. Possibly, under pressure nearly equalling that of the original rock pressure, an excessively volatile product would result, but inability to confine and to hold it would make its manufacture impracticable.

The best results are secured from gas from oil wells that are located in what is known as Gas Pump territory. On these wells a vacuum ranging from 10 to 22 inches, mercury column, is maintained.

WHAT VACUUM DOES.

This vacuum draws not only the gas from

the sand, but converts some of the lighter qualities of the oil into a vapor which assimilates with the gas. This gas under compression of 85 pounds, yields 4½ to 5 gallons of 92 gravity gasoline per 1,000 cubic feet. Increased pressure proportionately decreases the quantity of gasoline and raises the gravity. Under 165 pounds pressure 1,000 cubic feet of gas produced 3 to 3½ gallons of gasoline.

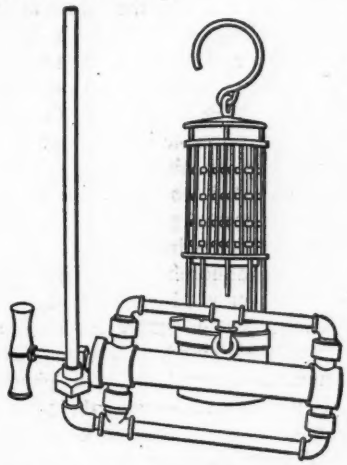
The gravity of the gasoline may be lowered to 78 degrees by proper treatment of the gas before it is put under pressure. It is a fact also that any gas which comes from an oil-bearing sand can be made to yield its product of gasoline under pressure not exceeding 150 pounds. There is an increasing demand for this high test product. For high speed gasoline engines and for the gas lighting machines it has no equal. The belief that the volume of gas is not diminished, and that there is no deterioration is, in our experience, incorrect.

The decrease in the volume of gas is in proportion to the amount of gasoline extracted —varying from 10 to 25 per cent.

Assuming that in the process of compression the water and other foreign substances are removed from the gas, and that no heat units are needed to eradicate this waste—there must still be deductions made from its former efficiency in proportion to its impoverished condition. It is true that a cleaner, brighter light is made from gas from which the gasoline has been taken, and it is true, also, that for gas engines this gas is superior, there being no danger of carbonization, but an additional 5 per cent. of the impoverished gas will be required.

NON RUSTING OF STEEL IN CONCRETE

The risk of the rusting of steel reinforcement in concrete has been widely discussed, and equally positive statements are made that it will and will not rust. The Concrete Institute has just issued a draft report upon this question. It is affirmed that if proper precautions are observed rusting will not occur. The materials used must all be of good quality and be well and scientifically mixed. The concrete should be mixed fairly wet and well packed, so that it fills the mold completely and leaves no voids. Sand more or less coated with salt should be washed, and salt water should not be employed for mixing. The stone or other aggregate should be as non-porous as possible. The aggregate should all pass through a ¾-in. mesh, and no coating of concrete should be less than ½ in. Where the concrete is much exposed to moisture the minimum thicknesses of concrete covering the reinforcement should be increased by 50 per cent. Paint, oil and thick rust should be removed from the reinforcement before it is put into its place. It is pointed out that these precautions are considered from the point of view of corrosion only.



TESTING FOR GAS IN COAL MINES

It is well known that the goaves of a coal mine are constant sources of danger from the collection of gas in them. They are also dangerous to inspect, owing to falling roof. In order to test these places in safety, Joseph Smith, inspector in the Phelps-Dodge mines, at Dawson, N. M., has invented the apparatus shown in the accompanying illustration. In using this device, the inspector carries enough ⅛-inch pipe with him to reach into the dangerous places. The pump is then connected to this pipe and the gas forced into the attached safety lamp, where the flame is watched. If the roof falls while the test is being made and the pipe cannot be withdrawn, it can be abandoned as a negligible loss. The pump can be used with any safety lamp by putting the pump discharge against the wires and working the pump, but it is arranged to fit the Wolf lamp.

The apparatus can also be used as a demonstrating device by taking any small tank, say an old fire extinguisher, putting a small quan-

tity of gasolene in it and drawing air through this tank and through another small tank in series, which serves as a mixing and storage tank, into a lamp. Any desired flame thus can be shown to fire bosses in entire safety. —*Engineering and Mining Journal.*

COMPRESSED AIR AT HIGH ALTITUDES

Mons. G. Trefois, in *Revue Universelle des Mines,* discusses mining conditions at high elevations, referring for illustration to the Sentein lead-zinc mines in the French Pyrenees. altitude 6,500 to 8,800 ft., and the Caylloma silves mines in Peru, altitude 16,000 ft.

The most noticeable and potent feature at these altitudes is the reduced atmospheric pressure, this at 8,150 feet being 27 per cent. less than the normal pressure at sea level, and at 16,300 feet the reduction being 45 per cent. The rarified atmosphere detracts from the efficiency not only of workmen and animals, but also of gas and compressed air engines.

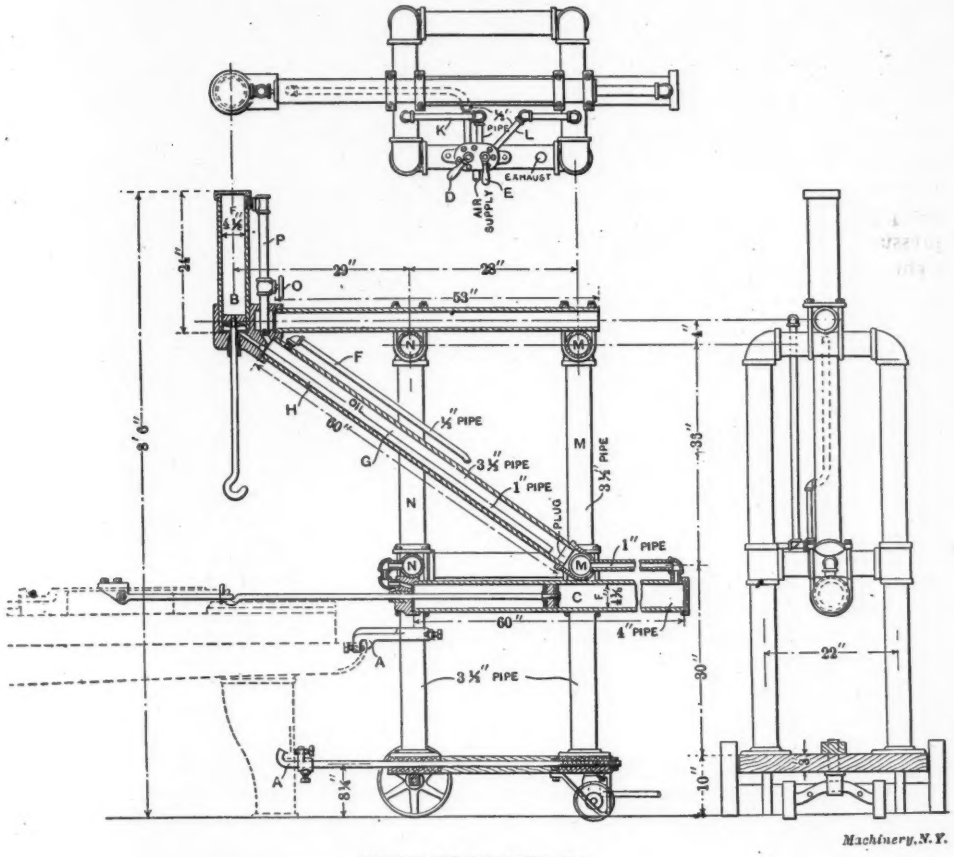
As now understood, mountain sickness is the cumulative result of two physiological phenomena: A congestion of blood in the lungs, whereby the movements of the chest and diaphragm are made more difficult, and a more rapid respiration, due to the necessity for inhaling a larger quantity of oxygen while the atmosphere actually contains less of it. It is plain that the effort thus required will diminish the amount of useful work that a man or animal can render. Relatively slight differences in elevation produce marked effects. Thus, at Sentein, the Bulard mine at 8,150 ft. is worked during the summer by laborers who during the rest of the year are engaged at the Bentaillou mine, at 6,500 ft.; the author estimates that the decrease in efficiency attributable to the diminished pressure of air alone, amounts to about 15 per cent., and yet the workmen are all accustomed to the conditions from their youth. It is not possible to make so close a comparison of efficiencies in the case of the Caylloma mines, since the men engaged in the mines are mostly Indians from the neighborhood, while those working at lower elevations are men of a superior type. The manager of these mines estimates that the loss of efficiency, as compared with workmen at sea level, amounts to about 50 per cent.

Exactly parallel results have been noted in the performance of horses and other animals. At Sentein it required a horse of exceptional strength to make two round trips per day, carrying a load of 50 kg. (110 lb.) a distance of 10 km. (6¼ miles) and climbing from an elevation of 3,260 to 6,520 ft., while in the valley, ordinary horses could readily cover twice this distance, with a load of 100 kg. At very high altitudes horses become disabled, and it is necessary to resort to mules and burros. The usual cost of transporting a piece of machinery weighing 350 lb., requiring a strong mule, is $20; pieces of less weight are carried on llamas at a cost of $10 per ton.

Mines at high altitudes are seldom able to use coal for fuel, owing to the cost of procuring it; wood is the common fuel of such mines. The effects of altitude are to lower the boiling point of water and also to reduce the back pressure of a non-condensing steam engine. At 8,150 ft., water boils at 92 deg. (198 F.) and the back-pressure is reduced to 555 mm. (21.85 in. mercury), and at 16,300 ft. water boils at 84 deg. (183 F.), the air pressure being only 415 mm., as compared with 760 mm. at sea level.

In regard to gas or gasolene engines, the weight of gaseous mixture drawn in at each stroke is approximately proportional to the atmospheric pressure, and while the author has not studied the question experimentally, he estimates that the loss of efficiency in such an engine will be about the same as in the case of an air compressor, amounting to 17 per cent., at 8,150 ft., and 25 per cent. at 16,300 feet. The efficiency of an engine using compressed air, owing to the diminished back pressure, is somewhat increased, but as this efficiency, in an air engine working underground, is seldom over 50 per cent., little of the energy lost at the compressor is regained through the fact that back pressure is diminished.

The highest railway point in the world is claimed for the Morococha branch of the Central Railway of Peru, which reaches an altitude of 15,865 ft. and has the highest station in the world at Ticlo (the junction with the main line), 15,665 ft. The maximum grade on the line, extending from the port of Callao, is 4½ per cent.



PNEUMATIC SCRAPING RIG.

PNEUMATIC HYDRAULIC APPARATUS FOR MACHINE SHOP SCRAPING

In the construction of precision machinery one of the most responsible operations of the shop is the scraping of the sliding surfaces so that they will fit accurately over practically their entire areas. This somewhat tedious operation consists in first rubbing the two surfaces together and then taking them apart and scraping away the initial spots which bear traces of contact. Upon rubbing the surfaces together again the areas of contact will be found to have been increased, but still to require successive rubbings and scrapings before the contact is satisfactory. The successive lifting off and replacing, and the working back and forth sufficiently to indicate the contact make the job a tedious one.

The apparatus here shown, the cut being reproduced from *Machinery*, was specially designed at the Jones & Lamson shops, Springfield, Vt., for this service. It is a combination hoist and pulling and pushing machine operated by compressed air in combination with oil, the air applying a pressure upon the oil which in turn exerts the required pressure upon the operating pistons and ensures steadiness and precision of operation. It is all mounted upon a truck so that it can be conveniently moved from one machine to another.

A lathe bed and slide to be fitted appear at the left of the cut. The machine is securely fastened to the lathe by the clamps *AA* as shown. The cylinder *B* is the hoisting cylinder, and cylinder *C* for the pushing and pulling. Valve *D* controls the pressure in cylinder *B* and valve *E* in cylinder *C*. When valve *D* is opened the air enters through pipe *F* into the oil chamber *G* from which the oil pressure is transmitted to the under side of the piston in cylinder *B*. When the piston and load is to be lowered the air is discharged

and the oil returning to reservoir *G* by means of the small pipe *H* prevents a too sudden drop.

When the horizontal movement is to be used the valve *E* admits the air pressure either to pipe *K* or to pipe *L*, from which it is transmitted to the oil in the reservoir formed by the pipes *M* and *V*, respectively. When the pressure is on *N*, the piston moves to the right, pulling the slide, and when the pressure is on *M* the piston pushes the slide in the opposite direction; the air pressure when admitted to one side of the piston being released from the other side. The pipe *P* and the hand-wheel-operated valve *O* permit any oil that may leak by the piston in cylinder *B* to return to the oil reservoir *G*. At the upper end of pipe *P* there is a small vent hole permitting the air above the piston to escape when the hoist is in operation.

CUTTING PROCESSES

Perhaps there are few things commonly done and generically described by a single word which can differ in character so widely and so essentially as do the various cutting devices and operations employed in the industrial arts and elsewhere. The typical cutting, and what the word first suggests, is that which is done with a sharp knife. The perfection of simplicity and ease in cutting is when we can say of anything that it cuts like cheese.

Next to the knife, and not very near it in kind, is the saw. The wedge action of the knife is here abandoned at once, and the teeth of the saw tear and drag the material. The cutting of the grindstone and the emery wheel is almost pure abrasion, so that the wear of journals and slides is a kind of cutting as far as it goes, and when the surfaces become dry and the abrasion is rapid cutting is the word we use for it. A cold chisel driven by a hammer has something of a wedge-like action when cutting soft steel or other tenacious metal, but when it gets to cast iron it rather breaks than pushes the material away; in cutting stone the breaking of the material is more pronounced, and still we call it cutting. Then comes the percussion rock drill, which could never cut stone as a knife cuts, but still works its way rapidly into the rock by its crumbling or pulverizing of the material.

All these ways and means of cutting have their special lines of employment, and in these lines neither could take the place of the other. The rotating twist drill would be worthless in a granite quarry, and the percussion rock drill could not penetrate steel plates or shape the surfaces of castings to precise dimensions in the machine shop. The different processes and apparatus have developed and have found their different employments in obedience to specific demands.

Perhaps nothing ever appeared more clearly responsive to an actual and well defined need of the worker than did the core drill. It is the earth sampler or taster, and tells the planner of great works, which will involve the cutting away of masses of rock and the penetrating to unfamiliar depths, what material will be encountered, so that he may make calculations and preparations in advance. It also tells the seeker for veins and beds of valuable minerals to be mined where he would waste his labour by penetrating and where he might be richly rewarded.

It is a curious thing that, to meet and satisfy this new requirement, we find cutting instruments and cutting processes still different from any of those above enumerated. The cutting of the diamond drill may best be characterized as a scraping action. The surface is scratched and the material is dragged away, being finely comminuted by the process of removal, so the result is the same.

The action of the shot in the Calyx drill, the successful and established rival of the diamond drill, would, at first, seem simple and evident enough. The individual shot, of course, become rollers, and as they pass over the surface, each bearing only upon a minute portion at a time, they crush or disintegrate by the rolling pressure, and the water washes the stuff away. This would seem to be very far from explaining the action when cutting through iron and steel, and we do not here attempt an explanation. Tools, like men, are judged ultimately by their record, and the records in this case not only of actual accomplishment, but of the cost of it, are indisputable. The records of the comparative costs of the cutting or abrasive or crushing elements, whichever we may choose to call them, give the "shot" drill a vast advantage, especially in the production of cores of such diameters as would be prohibitive by any other means practically available.

COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC

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McDONALD, THE SUBWAY BUILDER

John B. McDonald died in New York on March the 17th. At the time of his death he was receiving a salary of $50,000 per annum under a five-year contract with the Interborough-Metropolitan Company, and though he will always be known as the builder of the subway he is known throughout the United States as a contractor of rare skill and achievement. He was a poor Irish lad, with but little education, though when he died he was a Doctor of Sciences.

McDonald had a fine personality and was in every sense a good fellow; he was exceptionally companionable, and these characteristics, together with indomitable courage and energy led to his success. We learn from his career how a poor boy, with limited education, but with an abundance of energy and courage and no unusual ability, could push himself to the front and achieve renown and wealth. He was not in the class of shrewd, able, close-calculating contractors. His old partner Ryan, of the firm of Ryan & McDonald, was of this class; McDonald's great faculty was in the pioneer work leading up to and closing a contract, in getting financial backing and in securing sub-contractors or others to do the practical work in the contract which he controlled.

An incident of McDonald's career, which has never been published, occurred at the time of the building of the subway. The writer recalls distinctly a conversation at luncheon in New York when McDonald said that he had just attended a meeting of the board where the question of deciding the proper lengths of the subway stations was up for consideration. He said that he had much difficulty in getting them to increase the lengths of these stations. "Make them twice as long as your engineers have planned," said McDonald, "for the possibilities are very great. This subway," he said, "will be too small in a few years to take care of the traffic, and the stations will all be too small." This seems to have been prophetic, in view of the work which has been going on during the past year in lengthening the subway stations at an expense far beyond what the work would have cost if done when the subway was built.

It is easier to find men who can do good work than to find men who can make others do good work. McDonald was a director of

men. He got the best work out of others; he was a man instinctively of high integrity, too honest to make a large fortune out of his opportunities, too kind, generous and unselfish to accumulate. This barefoot boy passed away at a time when his career was at its height and when he was still young. He was buried from St. Patrick's Cathedral on Fifth avenue, New York. One's friends must be legion to fill this cathedral, yet it was packed to the doors by an audience that represented all the walks in life. It was distinctively a New York crowd; the man who carried a pick sat with bowed head by the side of the banker or the judge, and as the great doors of the cathedral swung open and the casket was borne into the aisle, preceded by bankers, judges and business men, the muffled notes of the cathedral chimes sounded the dirge:

Swift to its close ebbs out life's little day,
Earth's joys grow dim, its glories fade away.

And at that moment the power that animates the subway was shut off, the trains came to a standstill and all was dark.

W. L. SAUNDERS.

CHANNELING IN SHAFT SINKING AND TUNNELING

In the *Engineering and Mining Journal* of March 18, the statement is made that Mr. G. E. Wolcott has proposed a method of breaking ground in shaft sinking, drifting and stoping by the use of channeling machines, and it is suggested that the channeling machine used in quarries might replace the usual rock drill.

The suggestion is not new, as the Patent Office records bear ample proof. One of the original patentees on this subject proposed a plan by which a series of concentric channels, some 3 inches in width each, might be cut in the face of a heading or shaft and the material removed en bloc. The difficulty in this, as in all cases where channels are to be cut in rock, is to provide a machine for the purpose. It is an easy matter, for instance, to channel stone in quarries or open cuts where the space is unlimited and where the channeling is usually downward. Machines for this purpose are mounted on a track, they weigh several tons and consume from 15 to 40 H. P. in operation.

Channeling downward is the easiest way to channel, because the weight of the reciprocating parts aids the cutting. The greatest difficulty involved in any kind of channeling is to maintain the bits against a force of blow which is consistent with rapid progress. The wide use of channeling machines in quarries is due to the fact that the kind of stone quarried is usually soft or crystalline in structure, as for instance, marble, limestone and sandstone. Little or no progress has been made in channeling granite, because the material is hard and the progress slow, a hard blow on a chisel point working in an open channel resulting in steel breakages which make it necessary to either reduce the force of the blow or enlarge the width of the cut so as to admit of heavy steels, either of which alternatives entails slow progress and prohibitive expense. It is because of this that the harder rocks can be quarried at less expense by the usual process of drilling and blasting.

Another difficulty is that a machine to do expeditious channeling in a mine or heading occupies so much of the space that it is in the way when mucking is done, or when the material is removed. It must be taken entirely out of the way or shunted off on a siding.

It is really a mistaken idea that there is anything practical about channeling the rock out of a heading. It can be done, but it costs money to do it and that makes it prohibitive. Nobody is likely to pay a high price in mining work in order to get smooth walls to his tunnel or shaft. What is wanted is progress in excavation, economy of work and not aesthetic conditions. It is plain that dynamite when exerting its influence in a drill hole will aid in removing rock cheaper and better than a channeling machine. The channeling machine belongs to a class of work where saving of the rock taken out is important and where the shock of the blast might be serious.

This brings us to the consideration of a limited amount of channeling in order to reduce the shock of blasting, and here is the practical line on which to work. Instead of seeking to cut out the entire heading let the channeling be directed to make, say, a single cut in the heading, through the center vertically or horizontally, or at the bottom, as preferred. This channel might not be over 2 or 3 inches in width, but when made into the face it would make a double bench out of the heading. It would be a release line for the blasting to

work to. It should reduce the shock and the amount of powder required. This cut or channel is so simple that it can be made with a machine which is little more than a big rock drill working radially on a column or bar. Such a machine can be channeling while the rock drills are putting in the side holes, so that the whole operation is co-ordinate. A machine in this class, known as the Radialax, is used expeditiously in coal mines and in headings where the material is reasonably soft. It is hoped that its adoption will extend to rock headings and in that way substantially reduce the brutal shocks of heading blasts and minimize the liability of falls in mines which are frequently due to constant, heavy blasting.

W. L. SAUNDERS.

FOR CONTINENTAL RECIPROCITY

The reciprocity negotiations which are now under way between the United States and Canada are believed by many and will undoubtedly mark the beginning of an international agreement between the Republics of the western hemisphere, whereby free trade will be established and all restrictions of trade removed between these countries. Such an agreement cannot fail to result in a closer union of the countries concerned and do more towards their pan-Americanization than all of the other movements combined that have been inaugurated towards this end. At the present time the United States is combating with the problem of the high cost of living and seeking by legislation a means to reduce the prices on commodities controlled by monopoly. On the other hand the Latin-American countries afford the most promising export field for the industrial products of the States and if the barriers of trade were removed these products would find a greater field here and be able to compete more satisfactorily with manufacturers of Europe. The mineral and agricultural products of Mexico would find a ready sale in the markets of the United States and with the vast opportunities which the country affords in this direction a great development would take place. Not only would this movement be true of Mexico but all of the Latin-American countries and a trade would be induced which would be profitable to all nations concerned. The removal of the high import duty on zinc ore by the United States and the admission of manufactured steel commodities free of duty by Mexico, would result in an increase in trade along these lines amounting to millions of dollars annually and the same would be true of other commodities. It is to be hoped that this reciprocity movement which is now under way will not stop with Canada but spread throughout Latin-America as it would mean the beginning of a new era of commerce between these countries.—*Mexican Mining Journal.*

DR. RAYMOND RESIGNS

The resignation of Dr. Rossiter W. Raymond as secretary of the American Institute of Mining Engineers has been accepted by the council of the society. He is thus relieved from the onerous executive duties which have steadily increased and which suggested extensions of the societiy's work must still further augment. Dr. Raymond has been appointed secretary emeritus of the council, his services being retained for special editorial and other duties. We could wish that with his marvelous literary facility he might be able to make some valuable and enduring contribution to the world's treasures of autobiography and reminiscence.

Dr. Raymond was one of the founders of the Institute and in 1871 was elected vice-president, becoming also president the same year upon the resignation of David Thomas and being successively re-elected in the three following years. He has been secretary of the society for 28 years.

Dr. Joseph Strothers, the new secretary, has been connected with the institute as assistant secretary for eight years and as editor for five of those years. He was editor of *Mineral Industry* for four years and for many years was on the teaching staff of the department of metallurgy of the School of Mines of Columbia University.

EUROPEAN TUNNELS

The Loetschberg tunnel is approaching completion, the headings having met March 31st. Advancing at the rate of 27 feet a day on the north side and 19.3 feet on the south side, the tunnel has been driven with remarkable uniformity of progress. On the north side water continues to flow at the rate of nearly 50 gallons per second, and the temperature is 81 degrees, Fahr., while on the

south it rises to 90 degrees. The French are preparing a project for driving another tunnel through Mont Ceuis at a much lower level, at the same time reducing the gradients of the approaches. Another tunnel in course of construction and offering interesting features is the one through the Pyrenees connecting Aix-les-Thermes on the Midi line with Ripoll in Spain. From Aix-les-Thermes the railway follows the Merens Valley, and then, to avoid the heavy gradients at Saillens, it makes a complete turn round the Sagnens mountain. The line is then cut through the mountain sides until it reaches the Hospitalet Station. Over this part of the route the line is carried through short tunnels and under rock to protect it from snow and avalanches. From Hospitalet begins the biggest part of the undertaking, consisting of a tunnel 5,330 m. long through Puymorens. On the Spanish side good progress is made through granitic rocks; but on the Hospitalet side the schist rocks contain considerable quantities of water, which necessitates timbering, and the walling and roofing of the tunnel with concrete. It is expected that the new Trans-pyrenees line will be complete in four or five years.

AIR CONDITIONING

The mechanical control of the atmospheric conditions in buildings is of comparatively recent origin. While the necessity for pure air within enclosures has been recognized for many years, efforts have been chiefly confined to delivering outside air without treatment and to removing vitiated air, little attention having been given to the quality of air supplied. It seems to have been the idea that as long as the quantity of air suplied to a building was sufficient all requirements had been met, and there there was either no neeed of controlling the quality of the air or that such control was too costly to undertake. Now, however, it is recognized that efficient air conditioning really involves the regulation of temperature, of humidity and of purity. A supply of clean, fresh air, properly tempered, has a decidedly beneficial effect on the health of the operatives in a factory, and hence upon the amount and character of the work turned out. In foundries, storage-battery plants, potteries and various other manufacturing establishments, it is necessary to remove fumes or dust to protect the workmen. Aside from this hygienic aspect it is well known that in certain factories the successful operation of the manufacturing processes is to a large extent dependent upon the atmospheric conditions in which the work is conducted. This is especially true of the manufacture of textiles, gelatine products, photographic films and confections. In other places, such as coal mines and flour mills, the removal of fine particles of floating dust is imperative to prevent explosions, and it is in connection with the prevention of coal-mine explosions that air conditioning becomes such an important question. In cities where air is polluted by dust and smoke, no system of air conditioning can be complete that does not involve the use of air purifiers which consist either of cloth filters or of washers; the latter removing dust or other floating matter, and to a certain extent the soluble gases, by means of sprays or films of water. Air can be supplied to buildings by mechanical means with great uniformity as to quality and quantity, and in many cases the increased efficiency of employees more than offsets the cost of installation of the necessary ventilating plant.—*Engineering Record.*

WORLD'S GLYCERINE SHORTAGE

By W. Cullen.*

Most people know that the basis of the explosives which are consumed on the Rand, and indeed throughout South Africa as a whole, is nitro-glycerine. One might even go further and say the same holds for mining throughout the world, but this was not always so. In spite of the invention of compositions which were alleged to be many times as strong as nitro-glycerine, this body and explosives having it as their base now occupy a position which for rough and ready work is absolutely unchallenged, and will probably remain so. Nitro-glycerine, as you know is made from glycerine, which is a by-product of the soap and candle industry. It is not so very long ago since it was run to waste, and this continued until indeed nitro-glycerine found its place in the world of explosives. Now it has a value of £100 to £110 a ton, and the reason for this phenomenal advance may well

*From the Journal of the Chemical, Metallurgical and Mining Society of South Africa.

be asked. The question is easily answered. Quite apart altogether from the unique position of nitro-glycerine explosives as compared with others, their consumption as a class has increased enormously during the past two decades, but the phenomenal increase has been during the past decade. Every power which has a standing army has adopted powder which contains nitro-glycerine in greater or lesser proportion. This applies to the Japanese, among others, and Dr. Weiskopf is now manager of the factory where the explosives are made for the navy. Then, take our own South Africa. Within the last ten years the consumption has more than doubled; in Canada during the same period it has probably quadrupled, and even in the older European states the increase during the same period has been phenomenal. Then the Panama canal itself could take the entire production of Modderfontein or Somerset West. All this increase would not matter so much if the industries from which glycerine comes as a by-product were expanding correspondingly, but this is not so. People may be using more soap, but it is questionable whether they are using more candles. At any rate there has not been an expansion corresponding to that in the consumption of explosives, so the only thing which could possibly happen has happened. There is a shortage and prices have soared up. Some people are unkind enough to advance other reasons, but the one I have given is the true one and can be verified by independent examination. The position in a very short time, if it is not to-day, is that there is not enough glycerine to go around. The outlook is exceedingly serious, and that is why I sound this note of warning. People in the "know" have been trying to find a substitute for blasting gelatine for the past few years, and I am giving away no secret when I say that none has been found as yet, nor do I think it will be. Gelignite and gelatine dynamite do not offer so much difficulty, but I cannot give you the composition of any of the "substituted explosives" because I do not know them myself yet. I am safe in saying, however, that the existing processes at Modderfontein will be profoundly altered, as they will be in almost every factory in the world. How about mining? If a substitute for blasting gelatine is not found will our mining methods want modifying? My impression is that they will want profound modification. We shall have to find this out, and it is imperative that we start doing so now, for the changes which I have indicated will come about very soon. I appeal to mine managers and others to let us have facilities for carrying out experiments, and to assist us in every way they can, because although I am rather the reverse of an alarmist I must give it as my considered opinion that the position is a most serious one. Certainly explosives will not be lower in price for a very long time to come.

MAKING PERFECT BLUE PRINTS

Many novel and patented devices have from time to time been designed for the purpose of ensuring clear blue prints when printing in large frames. One of the simplest of these has been in use in a Belgian factory for many years, and has proved satisfactory in every way. In this factory the prints, which are in many cases of huge steam engines, have to be made an exceptionally large size, and the difficulty of ensuring perfect pressure of the paper in the frames is overcome by using thin rubber cushions the size of the frames, which are placed between the paper and the wooden back. Air is then blown into these cushions by means of the mouth, which gives just sufficient pressure to ensure perfect contact, without bulging the wooden back or the large glass front of the frame. By using this simple device the largest prints can be produced with perfectly sharp lines all through, and spoiled and blurred prints are entirely avoided.—*The Dodge Idea.*

SPIDER-WEB FISHING NETS

It is no longer possible to doubt that the natives of New Guinea use spider-webs for fishing-nets. A medalist of the Royal Geological Society, who has been traveling in New Guinea, reports that the natives bend the tip end of a long bamboo rod in such a way as to make a loop five or six feet in diameter. They set up this arrangement in the forest where the spiders are thickest, and wait for the insect to weave her web in the loop. The web has a mesh about one inch square at the outside, which gradually decreases in size to not more than an eighth of an inch square at the center. The native uses this as a scoop-net as he stands in the stream and dips the fish out as they come near. It is strong enough to hold fish weighing a pound. The spider which

makes it has a body about the size of a small hazelnut, with legs that spread out two inches.

WATER IN MINES

The depth at which water may be reached in an undeveloped mine, and the amount that will be present when it is reached are very uncertain. At many mines the water-level is surprisingly near the surface; altitude and topography have little influence. For instance, on Mount Union, southeast of Prescott, Arizona, the water-level in mines not drained by adits is close to the surface. This is at an altitude of nearly 8,000 ft., though down the valley of the Hassayampa river, which heads on Mount Union, there are mines over 200 ft. deep in which no water has been found. Some mines make a large volume of water between the surface and the 1,000-ft. level, but little or none below that depth. The Silver Islet mine, situated on a small island in Lake Superior, was worked to a depth of 500 ft., and was a remarkably dry mine.

COSTLY COMPRESSOR SAVING

In driving the Rivermont Tunnel on the Lynchburg cut-off of the Southern Railway, as described in a recent issue of *Engineering Record,* an unfortunate experience resulted from the use of steam instead of compressed air. A section of tunnel 360 ft. long, driven with much difficulty, was lost as the result of a fire which destroyed the crown timbering and threatened for a time to wreck the entire tunnel. A steam-shovel operated by steam had been allowed to stand in one place for some time, with the result that the timbering immediately above was dried out and took fire either from a spark or from the heat of the exhaust. An air-compressor plant had been installed, but the capacity was not great enough to supply both the drills and the shovel, and steam was therefore used for the latter in preference to installing an additional compressor. The decision to use steam was believed justified because of the large amount of water in the ground, resulting in thorough saturation of the timber as soon as it was placed. Had there been no change in the ground conditions the use of steam in the shovel might have been unattended by mishap, but the driving of the tunnel served to drain the water from the ground, and the creation of air currents through the tunnel after the headings met tended further to remove the moisture.

NOTES

A mixture of Pintsch gas with air is explosive within a gas percentage range of 5 to 13 per cent., and it develops its maximum power at about 9 per cent.

Mineral wool is glassy slag blown by compressed air into minute hair-like shreds. It is used as a non-conductor of heat for fireproofing and similar purposes. This is entirely different from steel wool, which consists of very fine steel shavings mechanically produced.

Experiments made by Russian investigators prove conclusively, according to *Practical Electricity and Engineering* that rubber is best preserved by immersion in distilled water. The preservatives tried were distilled water; lime water; soda, glycerin, carbolic, and boric acid solutions; alcohol; ammonium carbonate and benzine vapors; air; and vaseline and talcum powder.

A flight of stairs has been erected in Paris over which 14,000,000 persons have shuffled without so much as scratching the surface. These steps are almost as imperishable as if they had been built of huge diamonds, for in the concrete of which they are constructed a generous proportion of carborundum has been introduced, and since carborundum is almost as hard as the diamond, it has given the concrete a wearing quality which no marble or granite could possibly approach.

A power transmission plant is being erected at Lauchhammer, Germany, designed to generate current for transmission at a pressure of 110,000 volts, which is stated to be the highest voltage used for power transmission in Europe. The current transmitted is three-phase; the generator pressure is 5,500 volts, which is transformed up to the transmission voltage by four transformers, each of 6,800 kilowatt capacity.

According to Consul General Alexander M. Thackara, of Berlin, the greater number of factories use acetylene for welding in preference to hydrogen. Although the prices of acetylene and hydrogen are practically the same, German engineers claim that it requires from three to five times as much hydrogen as acetylene to do a given piece of work, while

hydrogen is not suitable for welding pieces more than 0.215 in. in thickness.

In the molten state aluminum absorbs nitrogen; the hotter the metal the greater is the absorption. The absorption of nitrogen from the atmosphere may be readily appreciated if a mass of aluminum skimmings be wet with water. Within a short time the mass will smell strongly of ammonia, showing that the water has been decomposed by the aluminum and formed ammonia from the nitrogen in it.

The term Baume gravity, which is in familiar use among petroleum operators and refiners, is apt to be confusing to those who are not acquainted with the method by which the system of units was established. For liquids lighter than water, among which is mineral oil, the Baume measurements are opposite to those of specific gravity. That is to say, the greater the specific gravity of the oil, the lower the Baume measurement, and vice versa.

Lifting gravel from a depth of about five hundred feet by means of compressed air is soon to be attempted on the property of the Crowley Brick Company, near Crowley, La. A pipe and device, such as are used in bringing oil to the surface in wells in Texas and Louisiana, are being installed by L. L. Lyons and John Burgin, who are experienced men in oil lifting operations. It is claimed that the gravel can be lifted from this great depth at comparatively small cost.

The loss of power in a gas engine owing to its installation at considerable elevations above sea level may be roughly estimated at about 3⅓ per cent. for each thousand feet. The decrease in barometric height is about one inch for 950 feet of altitude. This means that the weight of a given column of air will decrease by about one-thirtieth at the same time The weight of fuel taken in per revolution we may assume will be decreased in the same ratio, and also the number of heat units available.

In order to make his storage battery absolutely fool-proof, Mr. Thomas Edison devised a machine for abusing the battery in every known way, but Mr. Edison had to admit that when it came to inventing methods of abusing electrical apparatus, he could not compete with the "fool" operator. Try as he would to forestall every conceivable method of injuring the apparatus, some stupid man would devise a new and unthought of method for putting it out of business.

A motor fuel for aeroplanes should be chemically pure, of the lowest possible specific gravity, of the highest possible heat productivity, free of constituents with a high boiling point, and should not deposit any soot in the mechanism. The new petroleum product, aerobenzine, is of exceptional value. Its specific gravity should be from 0.620 to 0.590, and it should boil with the heat of the hand. The lower its specific gravity the purer it is. Aerobenzine must be kept in thick-walled hermetically sealed vessels that can stand great pressure.

From recent experiments in Germany it appears that, at a sufficiently high temperature, every kind of glass is completely soluble in water. Upon pressure, glass dissolves in water at 410 degrees, F. Seawater at a depth of 660 feet will not boil at that temperature, and if it penetrates the earth's crust where the temperature is equally high it will, apart from the pressure, liquefy the silicates or glassy rocks. The experiments point to the conclusion that at a depth of about five miles silicates in contact with water are virtually liquid, and that the level of aqueous fusion is five times nearer the surface than is that of igmous fusion.

The total output of all the air compressor plants employed on the Panama Canal work during the year ending June 30, 1910, was 7,227,203,513 cu, ft. of free air and the average cost was 4.03 cts. per 1,000 cu. ft.

Compressed air sewage ejectors were installed a few years ago in Guildford, England, to raise sewage from low lying areas and permit it to discharge into the basins at the sewage treatment works. There are eight of these ejectors in use with capacities ranging from 50 to 1,200 gals. per min. The compressed air for operating them is furnished by a power station, located adjacent to the town refuse destructor. The waste heat from this destructor generates sufficient steam to drive the air compressors which raise the sewage.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

MARCH 7.

985,792. SUCTION AIR-STRAINER. ALEXANDER ENGLAND, Wilkinsburg, Pa.

985,864. CONTROL-VALVE FOR WATER-JACKETED PUMPS. WALTER V. TURNER, Edgewood, Pa.

1. The combination with a water jacketed pump for compressing fluid, of means governed by the starting and stopping of the pump for controlling the admission of water to the water jacket of the pump, said means being also adapted to cut off the admission of water upon a pre-determined reduction in the pressure of the compressed fluid.

985,945. VACUUM-CLEANER. JOHN FRANCIS SHEA, Philadelphia, Pa.

985,957. RECEIVING APPARATUS FOR PNEUMATIC-DESPATCH SYSTEMS. HAROLD D. WATERHOUSE, Norfolk Downs, Mass.

985,965. PNEUMATIC CLEANING APPARATUS. ERNEST L. B. ZIMMER, Minneapolis, Minn.

985,966. DEVICE FOR TAKING MOISTURE OR OTHER VAPORS OUT OF GASES. HORACE W. ARNOLD, Vancouver, Wash.

985,972. TRACK-SANDING DEVICE. FREDERIC D. BOWEN and MENAN C. HAGLER, Monett, Mo.

985,986. MEANS FOR REMOVING AIR FROM HYDRAULIC TRANSMISSION-GEARS. RUDOLF EISERMANN, Berlin, Germany.

986,048. APPARATUS FOR REGISTERING THE FLOW OF FLUIDS. ALFRED J. DIESCHER, Pittsburg, Pa.

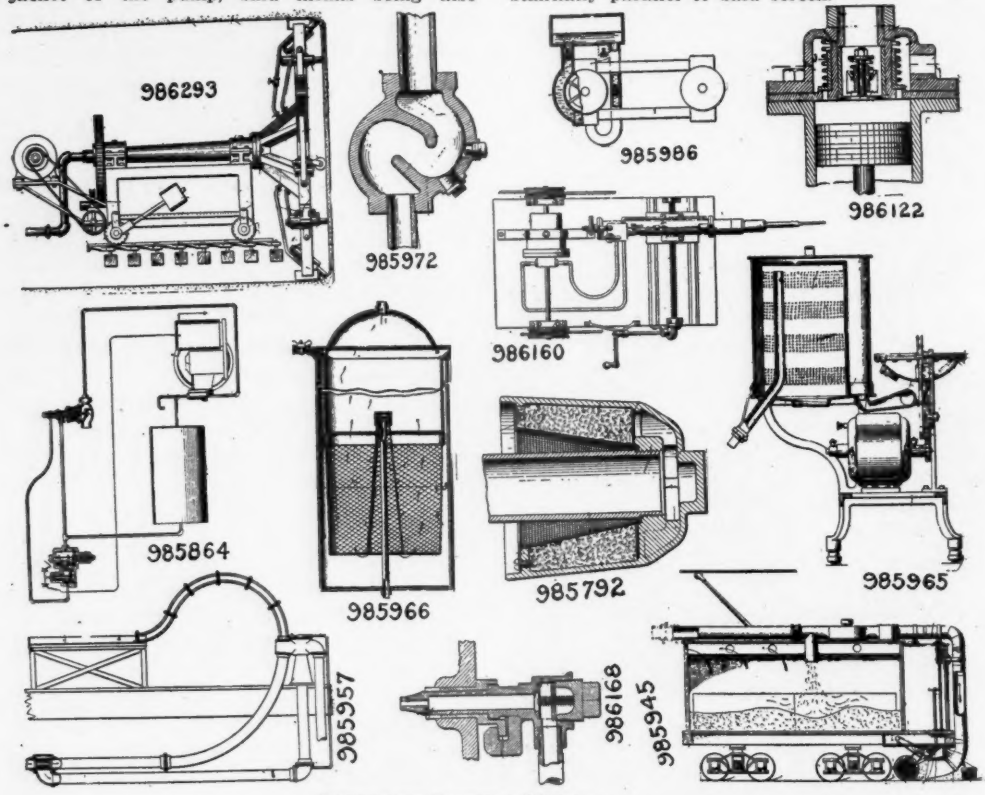
986,098. PNEUMATIC OPERATING DEVICE FOR STREET AND STATION INDICATORS. PERRY T. SPINDLER, Chicago, Ill.

986,122. VALVE MECHANISM FOR AIR-COMPRESSORS. JOHN ASTROM, Fort Wayne, Ind.

986,160. PNEUMATIC-HAMMER. CHARLES B. FRENCH, Kingston, Pa.

986,168. LOCOMOTIVE TRACK-SANDER. JOHN H. HANLON, Somerville, Mass.

1. In a pneumatic track sander the combination of a substantially horizontal conduit leading to an air nozzle, a screen located in said conduit and a second conduit entering said first conduit at a point just behind said screen and substantially parallel to said screen.



PNEUMATIC PATENTS, MARCH 7.

986,293. TUNNELING AND SHAFT-BORING MACHINE. FRANKLIN M. ILER, Denver, Colo.

986,403. SUCTION CLEANING-MACHINE. DAVID P. MOORE and SAMUEL B. PACK, Washington, D. C.

986,423. FLUID-METER. EDGAR P. COLEMAN, Buffalo, N. Y.; Robert H. Coleman, administrator of said Edgar P. Coleman, deceased.

MARCH 14.

986,495. PROCESS OF MAKING GAS. JOSHUA JOHN NIX, Alhambra, Cal.

1. The method herein described, of making a combustible gas, which consists in precipitating carbonaceous material into a receptacle, heating

said carbonaceous material with a restricted supply of air, inducting into said receptacle a supply of powdered carbon by aid of a partial vacuum, and supplying to said first-mentioned carbon and said powdered carbon within said receptacle a supply of steam.

986,502. ROTARY COMPRESSOR. AMANDUS CHARLES ROESSLER, Wandsworth Common, London, England.

986,577. APPARATUS FOR THE PRODUCTION OF COMPRESSED AIR. MICHAEL KIRILLOWITCH KIRILLOFF, Bakou, Russia.

1. The combination, in apparatus for the production of compressed air, of a bottomless bell, a tubular extension connected at the upper end thereof, a closing cap for the upper end of said tubular extension, and a concentrically arranged receptacle within the aforesaid tubular extension fitted at its lower end with a valve for effecting communication between the bottomless bell and said concentric receptacle, substantially as set forth.

986,663. ARTIFICIAL-GAS BURNER. JACOB WEINTZ, Cleveland, Ohio.

1. A gas burner, comprising three concentric tubes having a common orifice, a gas supply pipe connected with one of the tubes, an air supply pipe connected with another of the tubes, the third tube being divided into a plurality of longitudinal passages communicating at their outer ends with the atmosphere, and means for controlling such communication.

986,672. COMBINATION PRESSURE-GAGE AND PUMP CONNECTION FOR PNEUMATIC TIRES. DAVIS BARNARD, Los Angeles, Cal.

986,752. BLOWING-ENGINE OR COMPRESSOR. GUSTAV B. PETSCHE, Philadelphia, Pa.

986,797. STEAM, AIR, AND WATER TRAP-VALVE. JOHN E. BOEGEN, Berwyn, Ill.

986,907. RESPIRATORY APPARATUS FOR FIREMEN OR OTHERS. CHARLES E. CHAPIN, Elmhurst, Cal.

986,949. PNEUMATIC HOISTING-ENGINE. JOHN S. SHIELDS and WILLIAM LAMB, Detroit, Mich.

986,969. VEHICLE-SPRING. CARLOS ESCALANTE and JOSE PATRICIO SIRGADO, Merida, Mexico.

986,970. AIR-LOCK. WILLIAM H. FLAHERTY, New York, N. Y.

987,080. STEAM AIR-PUMP GOVERNOR. WILLIAM K. RANKIN, Philadelphia, Pa.

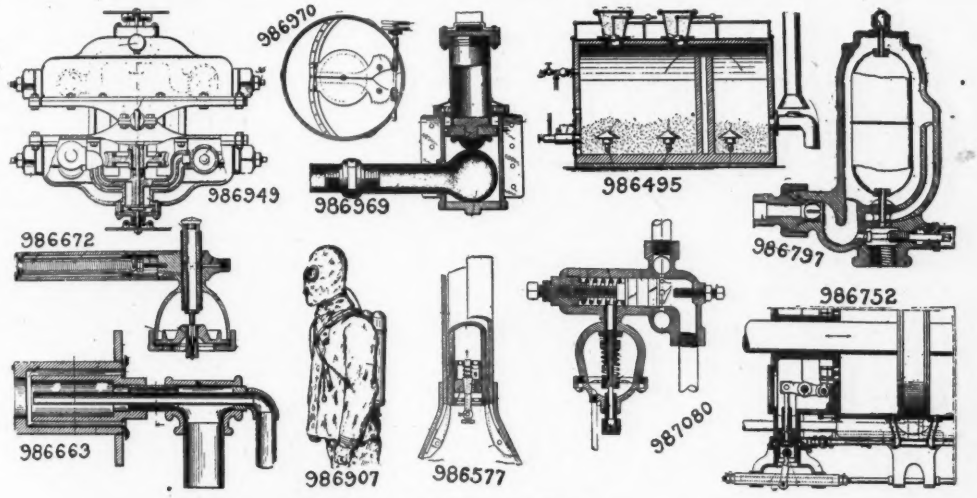
1. In a steam air-compressor governor, a chamber having a steam pressure entrance, a surrounding channel in communication with the chamber, a steam pressure outlet from the channel, a piston chamber and a piston therein, adjustable means to limit the piston's movements, resilient means to force the piston to close the steam pressure entrance, and cushion its return movement; an air pressure entrance to the piston chamber, a spindle valve adapted to close said entrance, and a diaphragm operative by air pressure to move away from the spindle valve and open the air pressure entrance to the piston chamber.

MARCH 21.

987,137. APPARATUS FOR BLOWING GLASS CYLINDERS. HARRY F. HITNER, Mount Vernon, Ohio.

987,158. POWER-GENERATOR. WILLIAM J. NEILSON, Elmhurst, N. Y.

1. A generating chamber, a perforated mixing chamber therein, means for injecting air into said mixing chamber, means for injecting hydrocarbon into said mixing chamber including a coil surrounding said mixing chamber, and means for injecting water into said generating chamber including a perforated coil surrounding the said mixing chamber, for the purpose and substantially in the manner described.



PNEUMATIC PATENTS MARCH 14.

987,160. CONSTANT-PRESSURE INTERNAL-COMBUSTION APPARATUS. EDWARD P. NOYES, Winchester, Mass.

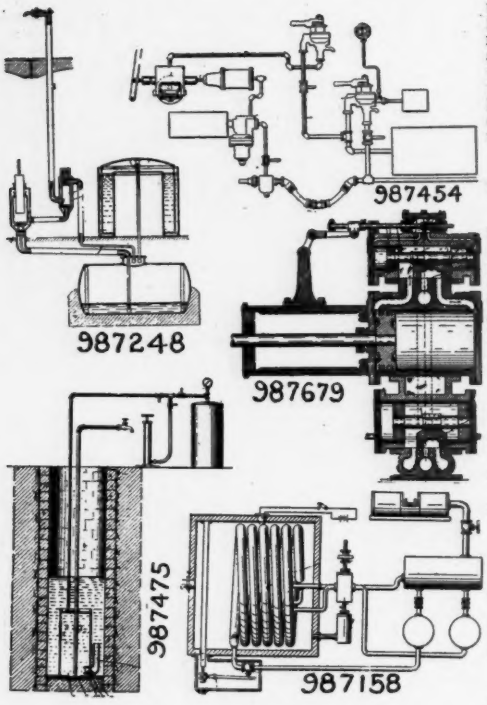
1. A generator for constant-pressure internal-combustion motor-systems comprising a closed combustion-chamber, a burner at the entrance thereof having passages for compressed air and fuel, an automatic resistance-valve at said entrance operated by the pressure of one of said fluids for controlling one or more of the fluids, and means in the path of one of the fluids immediately back of the point of issue thereof for producing a twisting motion of said fluid in the combustion-chamber.

987,248. DEVICE FOR FEEDING LIQUIDS. CARL MARTINI, Berlin, Germany.

987,454. AIR-BRAKE. JOHN W. ERSKINE, Mount Hope, W. Va.

987,475. WATER-DISTRIBUTING SYSTEM. HERBERT EDWIN MARTIN, Colorado Springs, Colo.

1. A water distributing system, comprising a tank adapted to be immersed in water, and having on its inner side near the bottom a ball valve, a pipe leading from near the bottom of the tank out through the top thereof and provided with a faucet, an air pipe leading from the top of the



PNEUMATIC PATENTS MARCH 21.

tank, a compressed air tank to which the air pipe is connected, an air pump, a flexible pipe connecting the pump with air pipe, and valves in the air pipe, one on each side of the connection of the pump with the said pipe, the valve farthest from the air tank being a three-way valve and having an opening in its casing with which one of the ports of the valve is adapted to register.

987,575. PNEUMATIC ACTION FOR MUSICAL INSTRUMENTS. OTTO HIGEL, Toronto, Ontario, Canada.

987,679. AIR-LIFT DISPLACEMENT PUMP. FRANK S. MILLER, Indianapolis, Ind.

1. In a displacement pump system, the combination with a pair of tanks having inlet and delivery pipes, and a compressor having delivery pipes leading into the two tanks, of a valve for controlling flow of air to and from said tanks, an air meter arranged between the compressor and said valve, and intermediate connections between said meter and valve for controlling th movement of the valve.

MARCH 28.

987,729. LIQUID AIR-LIFT. AUGUST LONG, Richmond, Va.

987,820. VACUUM CLEANING APPARATUS. PITMAN W. PARKER, San Diego, Cal.

987,837. APPARATUS FOR DRYING GRAIN. GRAY STAUNTON, Chicago, Ill.

987,870. PUMPING MECHANISM FOR VACUUM-CLEANERS. ABRAHAM LINCOLN FRAME, Reading, Pa.

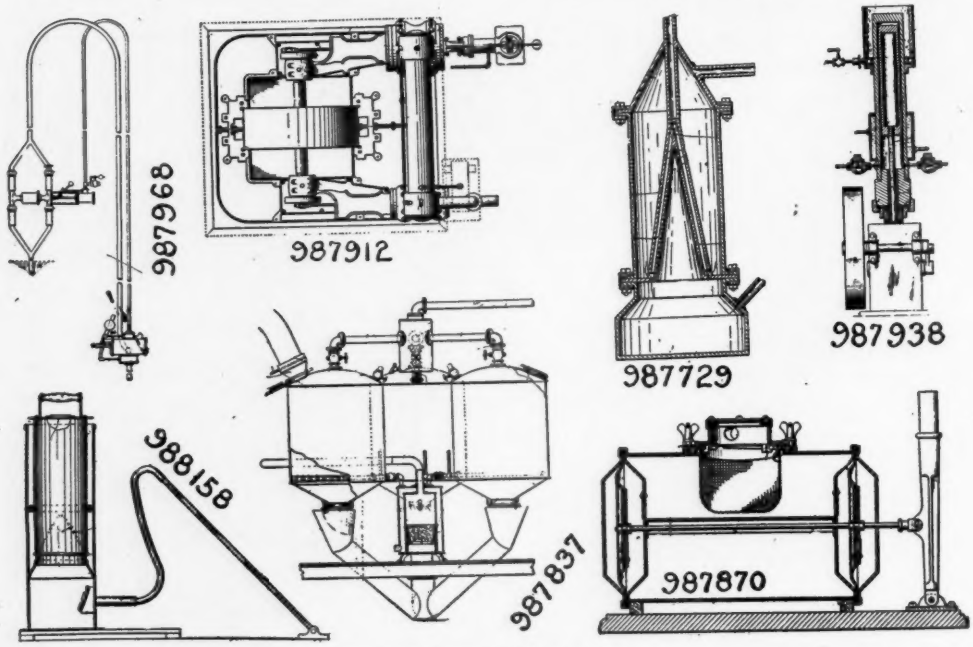
987,912. AIR-COMPRESSOR. WILLIAM PRELLWITZ, Easton, Pa.

987,938. HEAT-ACTUATED GAS-PUMP. CHARLES A. ANDERSON, Chicago, Ill.

987,968. METHOD OF SIPHONING FLUID. ROWLAND W. DAVIES, Pittsburg, Pa.

987,990. CONTROLLING DEVICE FOR PNEUMATIC PIANO-PLAYERS. HENRY S. HORNBECK, Elizabeth, N. J.

988,158. SUCTION DUST-REMOVING APPARATUS. HARRY WHITFIELD, London, and SAMUEL LAING WHITFIELD, Bedford Park, England.



PNEUMATIC PATENTS MARCH 28.

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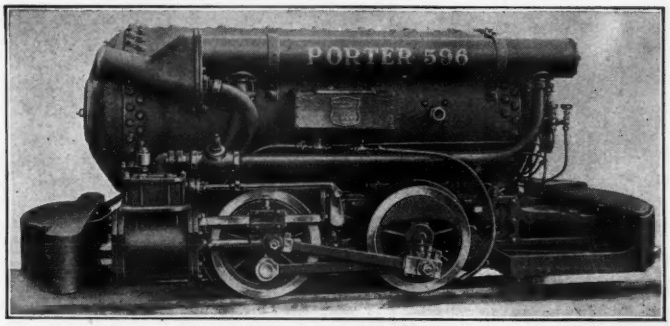

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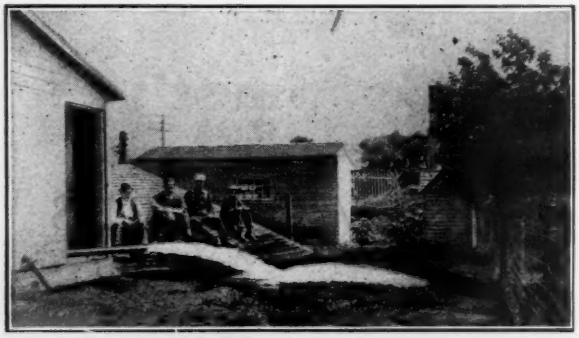

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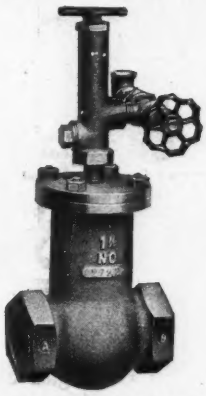

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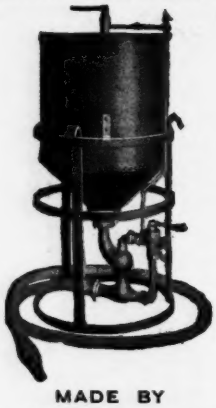

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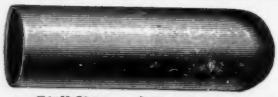
TANKS  TANKS
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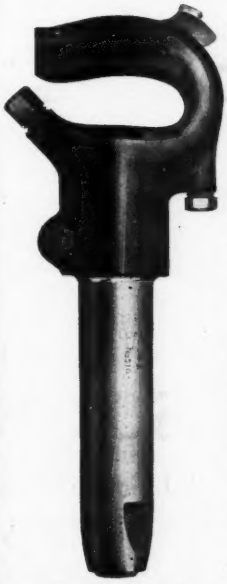

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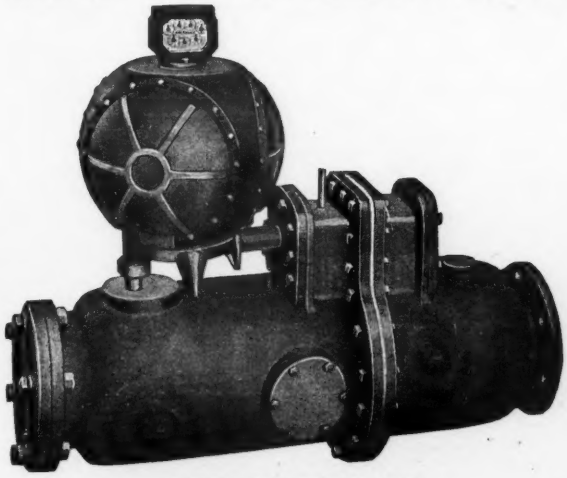

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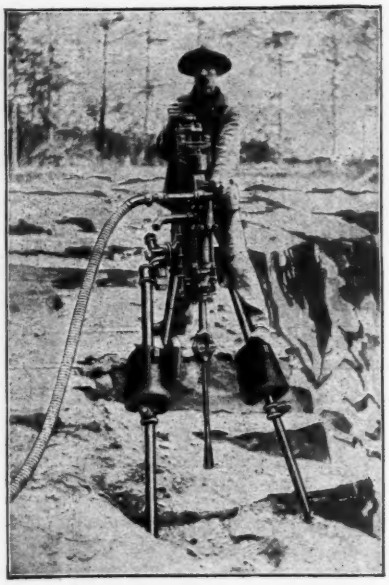

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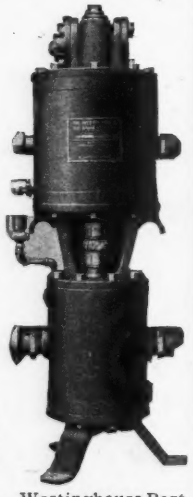

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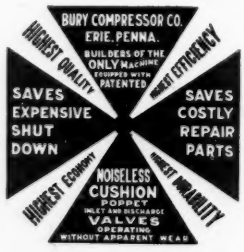
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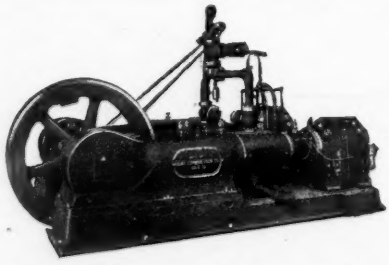

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